APPENDIX G

APPENDIX G

Standard Operating Procedures

Standard Operating Procedures

List of Procedures

- # 10003 Hand Auger Borings
- # 10004 Liquid Sample Collection and Analysis
- # 10005 Quality Assurance/Quality Control Measures for Field Activities
- # 10006 Soil Sampling
- # 10007 Installing and Developing Monitoring Wells and Piezometers
- # 10008 Hollow Stem Auger Soil Borings
- # 10009 Sediment Sampling in Shallow Rivers and Ponds
- # 10010 Shallow Surface Water Sampling and Flow Measurement
- # 10011 Geoprobe® Probing and Sampling
- # 10012 Sample Management Associated with the LEA Analytical Laboratory
- # 10014 Soil Vapor Sampling
- # 10015 Geologic Logging of Unconsolidated Sedimentary Materials
- # 10021 Performing Slug/Bail Tests
- # 10022 Conducting Step-Drawdown Pumping Tests
- # 10023 Conducting Constant-Rate Pumping and Recovery Tests
- # 10024 Geoprobe® Screen Point Groundwater Sampling
- # 10025 Rock Coring and Rock Descriptions

Standard Operating Procedure
for
Hand Auger Borings

SOP ID: 10003
Date Initiated: 2/20/90
Revision #004: 11/20/96

Approved By:

Name 1	Date 11/20/96
Gail L. Batchelder Name 2	11/20/96 Date

LEA

LOUREIRO ENGINEERING ASSOCIATES

Standard Operating Procedure For Hand Auger Borings

1.0 Statement of Purpose

This section discusses procedures for conducting hand auger soil borings either for exploration or for the installation of monitoring wells. The procedures provided in this text outline the advancement, decontamination, abandonment, and required documentation for the completion of hand auger borings. This document was prepared in accordance with ASTM D 1452 - 80. Soil sampling for chemical analysis is covered under "STANDARD OPERATING PROCEDURES FOR SOIL SAMPLING."

2.0 Equipment

2.1 Equipment required for conducting hand auger boring shall include:

- Hand auger (bucket or dutch)
- Auger extensions, wrenches, and handle
- Hand towels
- Portable VOC analyzer (Photovac Microtip® or equivalent)
- Polyethylene plastic sheeting
- Distilled water
- Field documentation
- Indelible marker
- Three 5-gallon buckets
- Alconox detergent, methanol, hexane, nitric acid
- Graduated cylinder
- Analytical balance (accurate to 0.1 gram)
- 500 ml disposable beakers
- Decontamination brushes
- Personal protective equipment
- Clipboard
- Pry bar

2.2 Utilities

2.2.1 Notify the appropriate "one call" utility notification service (e.g. Call Before You Dig) at least three working days prior to commencing operations on a site. The locations of all proposed borings must be clearly marked in the field prior to notification. The site manager MUST call and confirm that each utility has been to the site and has marked their respective lines.

2.2.2 Particularly upon larger private sites, consult with the Owner or other person knowledgeable about the site as to locations of potential private or abandoned utilities and locate these prior to beginning work. Upon the discretion of the Project Engineer/Manager, a pipe locator can also be used to assist in locating utilities.

2.2.3 Note that OSHA may have additional requirements for location of utilities.

2.2.4 All efforts to locate underground utilities should be properly documented in the field log book prior to onset of the work scheduled.

2.3 OSHA

The Senior LEA representative shall be the Competent Person required by OSHA for all work. However, this does not relieve other LEA representatives from bringing to his or her attention conditions which may be unsafe or present a hazard to the drilling crew, the general public, or other workers on the site.

2.4 Decontamination

2.4.1 All down-hole and sampling equipment will be sufficiently decontaminated prior to use. Decontamination procedures presented in site specific work plans may vary slightly from those presented below, dependent upon the particular types of contaminants encountered.

2.4.2 A section of 5-mil plastic sheeting shall be cut of sufficient size to underlie the decontamination area to contain any discharge of decontamination solutions.

2.4.3 The following solutions shall be prepared and placed in 500-ml laboratory squirt bottles: methanol solution (less than 10% solution); 10% nitric acid solution; 100% hexane solution; and distilled deionized (DI) water. A fifth solution of phosphate-free detergent and tap water (approximately 2.5 gallons) shall be prepared in a five-gallon bucket.

2.4.4 All loose debris shall be removed from the augers and spatulas into an empty 5-gallon bucket or plastic sheeting, using a stiff bristled brush.

2.4.5 The order of decontamination solutions is as follows:

1) Detergent Scrub
2) DI Water Rinse
3) Hexane Rinse
4) DI Water Rinse
5) 10% Nitric Acid Rinse
6) DI Water Rinse
7) Methanol Rinse (<10% solution)
8) Air Dry

2.4.6 Wrap each piece of decontaminated equipment in aluminum foil to maintain cleanliness.

2.4.7 At the end of the project day, all used equipment shall be decontaminated. Dispose of all spent decontamination solutions in accordance with all applicable municipal, state and federal regulations.

2.5 Water

2.5.1 Water is occasionally required to maintain the stability of the boring. If water is used, the source(s), quality, and volume(s) will be recorded on the boring log.

2.5.2 No other drilling fluid, may be used without specific authorization from the Project Manager.

2.6 VOC Monitoring

2.6.1 A portable volatile organic compound (VOC) analyzer shall be available on site and shall be used to screen all cuttings and fluids (if any) removed from the hole.

2.6.2 Since, in general, it cannot be presumed that a site is clean, all cuttings and/or fluids which show a reading on the VOC analyzer above background shall be containerized or drummed, as appropriate, on the site. Section 3.6 provides additional information on management of potentially contaminated fluids and materials.

2.6.3 All health and safety requirements shall be addressed in the Site-Specific Health and Safety Plan for each site.

3.0 Procedure

3.1 Site Preparation

3.1.1 A sufficient area shall be cordoned off to restrict access to the work area. This area shall be termed an "Exclusion Zone".

3.1.2 An equipment decontamination area shall be assembled, as described in Section 2.4, within the exclusion zone.

3.1.3 The area immediately surrounding the proposed borehole shall be covered with 5-mil plastic sheeting (minimum area: 10 square feet). A hole of sufficient diameter shall be cut from the center of the plastic sheeting to facilitate auger advancement.

3.1.4 All personal protective equipment shall donned.

3.1.5 Should flooring need to be breached for the advancement of the boring, coring of the floor will be conducted using a concrete coring saw and a wet-dry vacuum to prevent water and cuttings from moving beyond the immediate vicinity of the borehole.

3.2 Auger Advancement

3.2.1 Begin the boring by rotating and advancing the auger to the desire depth. Remove the auger and examine the soil for texture, composition, density, moisture and grain-size distribution. Record all information as described in Section 3.4.

3.2.2 The soils removed shall be logged in two-foot increments or at each lithologic change.

3.2.3 Collect a sufficient aliquot of the soil sample to satisfy all requirements for field and laboratory analysis. A lithologic sample may be required and should be obtained into a 4-ounce soil jar. The procedures for collection of soil samples for chemical analysis are described in the *Standard Operating Procedures for Soil Sampling*.

3.2.4 Discard boring spoils into the appropriate containers or onto the plastic sheeting for later disposal.

3.3 Field Analysis

3.3.1 The probe used to detect VOCs shall be either a Photovac Microtip® photoionization detector or a Foxboro OVA® flame ionization detector or equivalent and calibrated in accordance with the instructions provided by its manufacturer. Calibration shall be performed prior to each sampling event and checked after each day of sampling.

3.3.2 The following procedure shall be used to obtain readings of the VOCs present in a soil sample:

1) Obtain an aliquot of soil (approximately 50 grams) from the bottom of the auger and place it into a Ziploc® plastic bag or equivalent and seal.

2) Agitate the sample, assuring that all soil aggregates are broken, for two minutes.

3) Carefully break the seal of the bag enough to insert the VOC probe.

4) Record the maximum reading obtained on the appropriate forms, as described in Section 3.4.

3.4 Field Documentation

3.4.1 The following general information shall be recorded in the field log book and/or the appropriate field form(s).

- Site identification
- LEA commission number
- Site location
- Name of recorder
- Identification of borings
- Collection method

- Date and time of collection
- Types of sample containers used, sample identification numbers and QA/QC sample identification
- Field analysis method(s)
- Field observations on sampling event
- Name of collector
- Climatic conditions, including air temperature
- Chronological events of the day
- QA/QC data
- Name(s) of soil boring crew
- Location of boring on site in sufficient detail to relocate boring at a future time (include sketch)

3.4.2 The following information shall be recorded on the boring log:

- Project name, location, and LEA commission number
- Borehole number, borehole diameter, boring location, drilling method, field crew performing work, groundwater observations, logger's name and date
- Depth below grade, sample I.D. number, duplicate numbers, VOC analyzer reading
- A complete sample description, including as a minimum: depth, material size gradation using the Burmeister system, color, moisture, and density
- Should a well be constructed in a bore hole, a complete well schematic shall be drawn and accurately labeled
- Use of water, including source(s) and quantity

3.4.3 The following information shall be recorded on the Field Quality Review Checklist:

- Reviewer's name, date, and LEA commission number
- Review of all necessary site activities and field forms
- Statement of corrective actions for deficiencies

3.4.4 The Field Instrument & Quality Assurance Record shall include the following information:

- Client's name, location, LEA commission number, date
- Instrument make, model, and type
- Calibration readings

- Calibration/filtration lot numbers
- Field personnel and signature

3.5 Disposal of Potentially Contaminated Materials

3.5.1 Potentially contaminated cuttings or fluids, as indicated by knowledge of the site, discoloration, VOC analyzer readings, or other evidence, shall be containerized on the site pending sampling and determination of hazardous waste status.

3.6 Boring Abandonment

3.6.1 If the boring is not to be used for other purposes (i.e. monitoring well, soil vapor probe, soil vapor extraction well, etc.), it shall be abandoned.

3.6.2 The boring shall be filled and sealed with neat cement grout, or high-density bentonite clay grout.

3.6.3 Excess cuttings shall be containerized and sampled before disposal.

3.6.4 In paved areas, the upper three feet of the borehole shall be filled, up to two inches below the existing grade, with sand to allow for repairing of the pavement.

3.6.5 Pavement shall be repaired using cold patch asphalt filler or concrete.

4.0 Other

Depending on the specific site, other considerations may be applicable. Consult the OSHA regulations, applicable RCRA or CERCLA regulations, and the site-specific work plan for details.

Standard Operating Procedure
for
Liquid Sample Collection and Field Analysis

SOP ID: 10004
Date Initiated: 2/20/90
Revision #003 : 11/20/96

Approved By: ______________________ 11/20/96
Name 1 Date

Gail L. Batchelder 11/20/96
Name 2 Date

LEA

LOUREIRO ENGINEERING ASSOCIATES

Standard Operating Procedure
For
Liquid Sample Collection and Field Analysis

1.0 Statement of Purpose

This document describes procedures to be followed for measurement of static water level elevations, detection of immiscible layers, well evacuation, sample withdrawal, and field analyses.

2.0 Equipment

2.1 Equipment required for the collection and field analysis of liquid samples shall include:

- water-level indicator (accurate to 0.01 foot)
- distilled water
- hand towels
- portable VOC analyzer (Photovac Microtip®, Foxboro OVA® or equivalent)
- interface probe, clear pvc or fluorocarbon resin bailer
- pH and temperature meter (capable of accuracy to 0.1 pH unit)
- specific conductance meter
- two-inch diameter, PVC fluorocarbon resin or stainless steel bailers (clean) with disposable nylon rope
- polyethylene plastic sheeting
- centrifugal pump with fluorocarbon resin foot valve or equivalent
- peristaltic pump and polyethylene tubing
- clean disposable gloves
- 5-gallon bucket(s)

3.0 Sample Collection

3.1 Measurement of Static Water Level

3.1.1 The static water elevations in each well shall be measured prior to each sampling event. This is performed initially to characterize the site, and in subsequent sampling rounds to determine whether horizontal or vertical flow gradients have changed. A change in hydrologic conditions may necessitate modification of the groundwater monitoring program.

3.1.2 Each well shall have a surveyed reference point located at the top of the well casing with the locking cap removed. The reference point shall be easily recognizable, since the personnel conducting the sampling may differ from one sampling event to the next.

3.1.3 The following parameters shall be measured with an accuracy of ±0.01 ft:

- depth to standing water
- depth to bottom of well

3.1.4 A water-level indicator with a fiberglass tape will be used for measurement. Due to possible pressure differences between the well atmosphere and the ambient atmosphere, the water level will be allowed fifteen minutes to equilibrate upon removal of the well cap. The results shall be recorded on the appropriate field form(s).

3.1.5 Total depth measurements will be compared to original depths to determine the degree of siltation that may have occurred. This information shall be noted on the field form. Should significant siltation occur in any well, the well shall be redeveloped by an approved method.

3.1.6 The portion of the tape immersed in the well shall be decontaminated during retrieval using a distilled water rinse followed by drying with a clean wipe, prior to use in another well. This decontamination procedure shall be amended, as needed, to accommodate the specific type of contamination needed.

3.2 Field Analysis

3.2.1 Parameters that are physically or chemically unstable shall be tested immediately after collection using a field test kit or other equipment. Such parameters as pH, temperature, and specific conductance will be measured in the field, at the temperature of the well sample.

3.2.2 A standard pH meter with a glass or polymer-body electrode (Orion pH Meter model SA 250 or equivalent) shall be used. The meter shall be calibrated prior to use using two buffer solutions, in accordance with the instructions of the manufacturer of the meter. Calibration shall be checked using the two buffer solutions prior to sampling each well. Calibration information to be recorded in the field log will be the temperature and pH readings in each buffer before and after each calibration. The date the buffer was prepared shall also be noted in the field notebook.

The temperature and pH probes shall be placed into a sample and allowed to stabilize for a minimum of twenty seconds. The accuracy of measurement shall be 0.1 pH units and 0.1° Celsius. The sample shall be discarded in an appropriate manner upon completion of analysis.

3.2.3 Specific conductance will be measured using Cole-Parmer Conductivity Meter model 1481-55 or equivalent that has been calibrated in accordance with the instructions provided by its manufacturer. Calibration shall be performed prior to each sampling event and checked after each day of sampling.

The specific conductance probe shall be added to the sample container following measurement of the pH and temperature. The conductance meter will be adjusted for the temperature of the sample. Twenty seconds shall be allowed for stabilization prior to obtaining a reading. Accuracy shall be as stipulated by the range of the instrument.

3.2.4 These probes shall be decontaminated using a distilled/deionized water rinse between each sample. To the extent possible, the same probe and meter shall be used for all measurements at a given site for the duration of monitoring at the site.

3.3 Detection of Immiscible Layers

3.3.1 Should evidence warrant, a sampling event shall include provisions for detection of immiscible phases prior to well evacuation or sample collection. Light non-aqueous phase liquids (LNAPLs) are relatively insoluble liquid organic compounds with densities less than that of water (1 g/ml), while dense non-aqueous phase liquids (DNAPLs) are organic compounds with densities greater than that of water. Lighter and/or denser immiscible phases may be encountered in a groundwater monitoring well.

3.3.2 Remove the protective cover and locking cap.

3.3.3 The air in the well head will be sampled for volatile organic compounds (VOCs) using a portable VOC analyzer, such as a Photovac Microtip®. The instrument shall be zeroed with ambient air prior to the measurement, and the initial and final readings shall be recorded for each well.

3.3.4 An interface probe will be used to determine the existence of any immiscible layers, light or dense. Alternatively, a clear fluorocarbon resin or PVC bailer may be used to determine the existence of the phases or oil sheen in the well when no accurate determination of the immiscible layer thickness is required.

3.3.5 Should elevations of the immiscible layers be required, levels of the fluids shall be measured to an accuracy of 0.02 feet using an electronic interface probe capable of detecting the interfaces between air, product, and water. The interface levels shall be recorded in the field notebook. Adjustments of the observed head to the theoretical hydraulic head shall be calculated based on the density conversion factor associated with the particular non-aqueous phase liquid.

3.3.6 The immiscible layers and groundwater shall then be purged into 55-gallon 17H DOT drum which shall be labeled and characterized for disposal.

3.4 Well Evacuation

3.4.1 Calculate standing water in the well based on the following schedule and record on the appropriate field form:

Well Diameter (inches)	Conversion Factor (gal/feet)
2	0.163
4	0.654
6	1.47

3.4.2 Don disposable gloves, remove bailer from plastic bag, and attach nylon rope of sufficient length to reach the bottom of the well.

3.4.3 Lower the bailer gently into the water column and withdraw, being careful not to allow the rope or bailer to touch the unprotected ground.

3.4.4 Measure pH, temperature and specific conductance in the well from the first bailer extracted prior to purging.

3.4.5 Remove a volume of water equal to 3 to 5 times the standing water from the well measured in a 5-gallon bucket.

3.4.6 A new piece of polyethylene plastic shall be placed on the ground adjacent to the well. Sampling and purging equipment, such as bailers and bailer twine, pumps, containers, etc., shall be placed on the polyethylene sheet, never on the ground.

3.4.7 If it is not possible to remove three volumes as described above, due to slow recovery of the well, the well shall be emptied and allowed to recover. Samples obtained from slow-yielding wells shall be extracted as soon as a sufficient volume is available for a sample for each parameter.

3.4.8 Measure pH, temperature, specific conductance <u>prior</u> to sampling.

3.4.9 Well evacuation is deemed to be complete when the following criteria have been met:

- pH measurements vary no more than 0.5 units
- specific conductance measurements vary no more than ±10%
- temperature measurements vary no more than ±1 °
- turbidity measurements (if used) are below 5 ntu, if practicable

or a maximum of five well volumes have been removed from the well

3.4.10 Measure pH, temperature, specific conductance again <u>after</u> sampling to determine effectiveness of purging and sample stability.

3.4.11 Do <u>not</u> re-use purging equipment (bailers, rope, sampling vials, etc.). Bailers shall be returned to the office and decontaminated for future use (detailed bailer washing procedures described elsewhere in this manual).

3.4.12 Bailer twine and other consumables, such as filter apparatus, shall be disposed of appropriately.

3.4.13 Record sampler's name, sampling time, volume of water purged, parameters measured, weather conditions, sample number, analyses required and all other pertinent information in field notebook, and appropriate field forms, and complete the chain of custody form.

3.4.14 Alternatively, a centrifugal pump, peristaltic pump or equivalent, equipped with a fluorocarbon resin or PVC foot valve on the end of dedicated tubing may be used at shallow depths to evacuate the monitoring wells.

3.4.15 If any indication that the water purged is or may be hazardous, store the liquid until the appropriate laboratory analyses are available, then dispose of it according to all applicable local, state and federal requirements.

3.4.16 Storage shall be in containers approved for storage of hazardous materials, and in an appropriate designated location at the facility.

3.5 Sample Withdrawal

3.5.1 In order to ensure that the groundwater sample is representative of the formation, it is important to minimize physical alteration (i.e. agitation during purging and/or sample collection) or chemical contamination of the sample during the withdrawal process. The sample set shall include enough dedicated bailers to obtain samples from each well, plus 10%.

3.5.2 Use a PVC, fluorocarbon resin or stainless steel bailer to purge each well (the same bailer used for purging may be used for sample withdrawal). Do not reuse a bailer in the field; used bailers shall be returned to the office for decontamination.

3.5.3 Samples shall be collected in the following order into pre-labeled sample containers:

- Volatile organic compounds (VOCs)
- Purgeable organic carbon (POCs)
- Purgeable organic halogens (POX)
- Total organic halogens (TOX)
- Total organic carbon (TOC)
- Extractable organics (semi-volatile)
- Metals
- Phenols
- Cyanide
- Chloride and sulfate
- Nitrate and ammonia
- Turbidity
- Radionuclides

3.5.4 Samples shall be obtained from the monitoring wells as soon as possible after purging. This may require waiting an extended period for low-yielding wells.

3.5.5 Samples collected for VOC analysis shall be free of any air bubbles and inverted upon filling. Bacterial samples shall be collected using dedicated gloves; taking care not to allow anything to touch the inside of the sampling container.

3.5.6 Samples collected for metals analysis shall be filtered in the field through 0.45 micron (maximum) membrane filter under negative pressure.

3.5.7 In situations where replicate samples shall be required, care shall be taken to ensure that each sample collected is independent.

3.5.8 In some situations, inorganic parameters may be sampled directly from a pump after completion of well evacuation procedures.

3.6 Field Documentation

3.6.1 Field documentation shall include at a minimum: a chain-of-custody form, field log notebook, Field Data Record Groundwater Form, Sample Collection Form, Daily Field Report, Field Quality Review Checklist. Sample labels and sample seals shall be used for proper sample identification.

3.6.1.1 The labels shall be sufficiently durable to withstand immersion for 48 hours without detaching and to withstand normal handling. The information provided shall be legible at all times.

3.6.1.2 The following information shall be provided on the sample label using an indelible pen:

- Sample identification number
- Date and time of collection
- Place of collection
- Name of collector
- Parameter(s) requested (if space permits)

3.6.1.3 A field logbook and/or appropriate field forms will be used to log all pertinent information with an indelible pen. The following information shall be provided:

- Identification of well
- Static water level measurement technique
- Presence of immiscible layers and detection method

- Well yield - high or low
- Time well purged
- Collection method for immiscible layers and sample identification numbers
- Well evacuation procedure/equipment
- Sample withdrawal procedure/equipment
- Date and time of collection
- Types of sample containers used and sample identification numbers
- Preservative(s) used
- Parameters requested for analysis
- Field analysis method(s)
- Field observations on day of sampling event
- Name of collector
- Climatic conditions, including air temperature
- Internal temperature of field and shipping (refrigerated) containers

3.6.1.4 The Field Sampling Record shall include at a minimum the following information:

- Identification of well
- Date and time of collection
- Field analysis data and method(s)
- Name of collector
- Sample number

3.6.1.5 The chain-of-custody record shall include the following information:

- Company's name and location
- Date and time of collection
- Sample number
- Container type, number, size
- Preservative used
- Signature of collector
- Signatures of persons involved in the chain of possession
- Analyses to be performed

3.6.1.6 The Field Data Record Groundwater Form shall be updated during the sampling of each well and include the following information:

- Identification of well
- Well depth, elevation of casing and riser, diameter depth to water, water table elevation
- Static water level depth and measurement technique
- Purge volume and pumping rate
- Time well purged
- LEA commission number
- Date
- Project and site location
- Inspectors and time of inspection
- Record of non-productive time
- Type and number of samples, total number of sample bottles, and sampling method
- Status of total production
- Record of site activities

3.6.1.7 The Field Quality Review Checklist shall assure the completeness of the sampling round and include the following information:

- Reviewer's name, date, and LEA commission number
- Review of all necessary site activities and field forms
- Statement of corrective actions for deficiencies

Standard Operating Procedure
for
Quality Assurance/Quality Control Measures
for
Field Activities

SOP ID: 10005
Date Initiated: 2/20/90
Revision #002: 8/25/94

Approved By: ______________________ 8/25/94
Name 1 **Date**

Gail S. Batchelder 8/25/94
Name 2 **Date**

A:\SOPS.#\10005

LOUREIRO ENGINEERING ASSOCIATES

Standard Operating Procedure For Quality Assurance/Quality Control Measures For Field Activities

1.0 Statement of Purpose

This document describes procedures to be followed for proper Quality Assurance Quality Control (QA/QC) practices which shall incorporate all activities associated with sampling tool and instrument preparation, field measurements and sampling, proper documentation of field and post-field activities, QC sample preparation, chain-of-custody protocol and laboratory analytical procedures. The use of specific QA/QC measures shall be dependent upon the goals of a particular project and shall be stated in the site specific work plan. This SOP was adopted in accordance with the EPA document "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846)".

1.1 General

1.1.1 All QA/QC sample preparation procedures shall be properly documented including:

- Name of person(s) or laboratory involved in sample preparation
- Reagents used
- Sample number
- Analyses required
- Concentration calculations
- Accuracy of measurements
- Number, type, size of containers used
- Preservation method
- Date and time of sample preparation

1.1.2 All information shall be included in the field logbook, but not necessarily in the chain-of-custody record except as needed for proper sample identification and analysis. No information that would identify the sample as a QA/QC sample shall be included in the chain-of-custody record.

1.1.3 At the conclusion of each sampling day, a quality control review shall be conducted using the Field Quality Review Checklist and the Daily Field Report.

2.0 QC Sample Preparation

2.1 Trip Blank

2.1.1 Contaminated trip blanks may indicate contamination of the samples during the field trip or shipment to the lab, cross contamination between the samples, contaminated sample vials or improper handling.

2.1.2 Trip blanks are prepared using analyte-free deionized water prior to the sampling event. They are placed in the same type of bottle or container as the sample(s) to be collected for which they serve as a blank, and are carried in the same shipping container as that sample or samples.

2.1.3 Trip blanks shall be used with volatile and semi-volatile organic samples only.

2.1.4 One trip blank shall be included per sample bottle/preservation technique/analysis procedure per sampling day.

2.2 Field Blank/Equipment Blank

2.2.1 The purpose of a field blank/equipment blank is to determine if decontamination procedures were adequate.

2.2.2 A field blank/equipment blank is prepared by running analyte-free deionized water through sample collection equipment (bailers, pumps, filters, split spoon) and placing it in the appropriate sample containers for analysis. The field blank is treated exactly as another monitoring well, and thus has its own associated bailer, filter apparatus, and other expendable equipment and is treated precisely as a monitoring well sample, except that, obviously, it is from a bottle rather than from a well.

2.2.3 Field blanks shall be used when sampling surface water, groundwater, soil sediments and soils.

2.2.4 One field blank shall be collected for each sample bottle/preservation technique/analysis procedure per matrix per sampling event.

2.3 Replicate Samples

2.3.1 Replicate samples provide precision information on handling, shipping, storage, preparation and laboratory analysis.

2.3.2 Replicate samples are samples that have been divided into two or more portions in the field. An example of a replicate sample is two identical sample bottles filled with water from the same bailer retrieval. To ensure homogeneity, the bailer should be emptied into a clean, decontaminated beaker used exclusively for the purpose and containing sufficient volume for both sample containers, and from that into the sample containers.

2.3.3 Replicate samples can <u>not</u> be used when sampling for volatile organic compounds.

2.3.4 One replicate sample shall be obtained for each sample bottle/preservation technique/analysis procedure per sampling event or one out of every 20 samples, unless collocated samples are used (see below).

2.4 Collocated Samples

2.4.1 Collocated samples provide precision information on sample acquisition, homogeneity, handling, shipping, storage, preparation and laboratory analysis.

2.4.2 Collocated samples are independent samples collected in such a way so that presumably they are equally representative of the parameter of interest. Examples of collocated samples are groundwater samples collected sequentially, soil core samples collected side-by-side, or air samples collected essentially at the same time from the same manifold.

2.4.3 Collocated samples are especially useful when sampling for volatile organic compounds, for which replicate samples cannot be used.

2.4.4 Collocated samples shall be obtained for each sample bottle/preservation technique/analysis procedure per sampling event or one out of every 20 samples, unless replicate samples are used (see above).

2.5 Split Samples

2.5.1 The purpose of split samples is to provide an assessment of the laboratory analytical procedure.

2.5.2 Split samples are collocated or replicate samples sent to two (or more) different laboratories.

2.5.3 Split samples can be used with any sample media. Split samples can be used in conjunction with spiked samples (see below). In case contradictory results are obtained from the samples split between different laboratories, the spiked samples can be used to verify the analytical data (provided that the spiked samples were properly prepared and the appropriate documentation is available).

2.5.4 When used, one split/spiked sample per sample bottle/preservation technique/analysis procedure per sampling event or every 20 samples shall be included.

2.6 Spiked Samples

2.6.1 The purpose of spiked samples is to provides information on the precision of the laboratory analytical procedure. However, besides a wrong preparation, several other sources of error exist such as analyte stability, holding time and interactions with the sample matrix.

2.6.2 Spiked samples are samples spiked with the contaminants of interest. The compounds used for spiking should be of the same chemical group as the contaminants being investigated, but they do not have to be the exact chemical compounds. Spiking should be carefully designed and performed prior to the field investigations. Field matrix spikes are not generally recommended because of the high level of technical expertise required for proper preparation and documentation.

2.6.3 Can be used with any sample media, however, liquid matrices are preferred due to uniformity of mixing.

2.6.4 When used, one split/spiked sample per sample bottle/preservation technique/analysis procedure per sampling event or every 20 samples shall be included.

Standard Operating Procedure
for
Soil Sampling

SOP ID: 10006
Date Initiated: 2/20/90
Revision #003: 11/21/96

Approved By:______________________ 11/21/96
Name 1 **Date**

Gail T. Batchelder 11/21/96
Name 2 **Date**

LEA

LOUREIRO ENGINEERING ASSOCIATES

Standard Operating Procedure for Soil Sampling

1.0 Statement of Purpose

This document discusses procedures for collection of soil samples for analytical analysis. Methods for collection and quality assurance/quality control requirements are covered under separate SOPs. The procedures outlined in this document are in accordance with ASTM Standard D 420 and the EPA document Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846). These procedures may vary slightly according to the needs of specific projects.

2.0 Equipment

2.1 Equipment required for the collection of soil samples shall include:

- Stainless steel spatula
- Distilled water
- Hand towels
- Polyethylene plastic sheeting
- Sample collection jars
- Clean disposable gloves
- Field documentation
- Indelible marker
- Cooler, cold packs and maximum/minimum thermometer
- Custody seals and sample labels
- Polythethylene plastic sheeting (5-mil thickness)

2.2 Cleaning and Decontamination

2.2.1 Prior to conducting a boring, the LEA representative will ensure that all necessary sampling equipment is clean and decontaminated according to the site-specific work plan or collection method SOPs.

2.2.2 Upon completion of all sampling requirements and prior to leaving the site, all equipment used for sampling shall be cleaned and decontaminated. All generated decontamination fluids shall be disposed of in accordance with the site-specific work plan and all municipal, state, and federal requirements.

3.0 Sampling Protocols

3.1 Preliminary Sampling Procedures

3.1.1 Sample Bottles

3.1.1.1 A Laboratory Request Form shall be completed and submitted to the laboratory with following information:

- Project name
- LEA commission number
- Date of submittal and date needed
- Quantity of sample locations and sample points at each location
- Type(s) of samples
- Analytes, detection limits and QA/QC needed
- Cooler(s) required
- Number of Chain-of-Custody forms requested

3.1.1.2 Check bottles against Laboratory Request Form for completeness. The bottles should also be checked for damage and cleanliness. Confirm with laboratory personnel the adequacy of the preservatives used.

3.1.1.3 Label all bottles prior to sampling with the information and check for accuracy. This step may also be performed in the field prior to sample collection.

3.1.1.4 The total number of sample sets shall be increased by 10% to allow for possible breakage during transport to sites or other contingencies (minimum: one additional sample bottle set per event).

3.1.1.5 A cooler with adequate ice or cold packs should be obtained from the laboratory to insure that the collected samples remain at 4°C during transport. Packing material should also be obtained to insure against breakage during transport.

3.1.2 Site Preparation

3.1.2.1 A level table shall be placed within the exclusion zone and covered with polyethylene sheeting.

3.1.2.2 Decontaminated spatulas shall be wrapped in aluminum foil and placed on the table. Prelabeled sample bottles shall be placed in a convenient location and in order of sample collection.

3.2 Sampling Procedures

3.2.1 All personal protective equipment (PPE) should be donned and maintained in accordance with the site-specific work plan or health and safety plan during all sampling procedures. In the event that no PPE has been specified for a particular sampling event, disposable latex gloves should be donned, as a minimum, during all sampling procedures.

3.2.2 The particular soil sampling device (i.e. hand auger, split spoon, etc.) shall be retrieved from the point of collection and placed on a level table covered in polyethylene sheeting.

3.2.3 Using a decontaminated stainless steel spatula, the soil shall be transferred directly into a prelabeled soil sampling container. Care should be taken to completely fill the sample container. Large void spaces within the container shall be minimized by packing, <u>not</u> agitation.

3.2.4 Wipe the rim of the sample container with a clean paper towel to remove excess solids which would prevent adequate sealing of the sample container and seal the container.

3.2.5 Affix a custody seal, noting the date and time of collection across the cap/bottle interface and on the sample label. Place and secure sample within cooler and complete all sample collection documentation.

3.3 Post-Sampling Procedures

3.3.1 Upon completion of all sampling procedures for a particular site, secure the lid of the cooler using packaging tape with the Chain-Of-Custody inside.

3.3.2 Should the laboratory be local, transport the samples directly to the laboratory and present them to the sample manager. The representative of LEA should witness the verification of the Chain-Of-Custody and obtain a carbon copy for filing in the project notebook.

3.3.3 Should the laboratory be distant, arrange for transport with a reputable carrier service. The cooler and samples shall be secured for transport, and all mailing documentation secured onto the top of the cooler. Unless otherwise specified, delivery shall be overnight. A request for confirmation of acceptance should be made to the carrier at the time of pick-up.

3.4 Documentation

3.4.1 The following general information shall be recorded in the field log book and/or on the appropriate field forms:

- Site identification
- LEA commission number
- Site location
- Name of recorder
- Identification of borings
- Collection method
- Date and time of collection.
- Types of sample containers used, sample identification numbers and QA/QC sample identification
- Preservative(s) used
- Parameters requested for analysis
- Field analysis method(s)
- Field observations on sampling event
- Name of collector
- Climatic conditions, including air temperature
- Internal temperature of field and shipping (refrigerated) containers
- Chronological events of the day
- QA/QC data

3.4.2 The following information shall be recorded on the Field Quality Review Checklist:

- Reviewer's name, date, and LEA commission number
- Review of all necessary site activities and field forms
- Statement of corrective actions for deficiencies

3.4.3 The following information shall be recorded on the chain-of-custody record:

- Client's name and location
- Boring or sampling location identification
- Date and time of collection
- Sample number
- Container type, number, size
- Preservative used
- Signature of collector
- Signatures of persons involved in the chain of possession
- Analyses to be performed

3.4.4 The following information shall be provided on the sample label using an indelible pen:

- Sample identification number
- Name of collector
- Date and time of collection
- Place of collection
- Parameter(s) requested (if space permits)

3.4.5 The following information shall be recorded on the sample collection data sheet:

- Client name, location and LEA commission number
- Boring or sampling location identification number
- Date and time of collection
- Sample number
- Depth sample was obtained
- VOC reading

Standard Operating Procedure
for
Installing and Developing Monitoring Wells and Piezometers

SOP ID: 10007
Date Initiated: 2/20/90
Revision #003: 11/21/96

Approved By:

Name 1 — Date 11/21/96

Gail S. Batchelder — 11/21/96
Name 2 — **Date**

LOUREIRO ENGINEERING ASSOCIATES

Standard Operating Procedure
for
Installing and Developing
Monitoring Wells and Piezometers

1.0 Statement of Purpose

This standard operating procedure (SOP) is designed to describe the methods and procedures used to install and develop monitoring wells and piezometers in a water-table aquifer. Monitoring well and piezometer installation and development should generally follow the guidelines presented in "Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells" (US EPA, 1991), the "RCRA Ground Water Monitoring Technical Enforcement Guidance Document" (US EPA, 1986), and any state or local guidance or regulatory documents which are available.

This SOP describes general procedures and guidelines to be followed or consulted for the proper methods to be used when installing water-table monitoring wells or piezometers. Because each site is unique and the purpose of the monitoring wells may vary from installation to installation, no definitive rules can be established. Throughout this SOP reference to monitoring wells is also intended to mean piezometers unless specifically indicated otherwise.

2.0 Equipment and Decontamination

2.1 Equipment Supplied by the Drilling Contractor

- Drilling rig
- Monitoring well casing
- Monitoring well screen
- Bottom caps, plugs or points
- Centering guides (if they are to be used)
- Filter pack sand
- Bentonite
- Cement-bentonite grout
- Mud-scale to measure densities
- Protective casing or roadbox

- Well development equipment (The exact equipment necessary will depend upon the type of well development that is to be done. For surging and bailing this includes: surge block and fittings, and sand bailer or sand pump. For overpumping this includes: pump, discharge hose, water-level indicator, and power source.)
- Steam-cleaning apparatus and supplies
- Suitable containers (e.g., DOT-approved 55-gallon drums with liners) for soil cuttings, well development water, and water generated from steam cleaning.
- Metal stamps for permanently marking wells
- All necessary permits and licenses

2.2 Equipment Supplied by LEA

- Field forms
- Indelible markers
- Lock(s) and keys
- Analytical instrumentation (Analytical instrumentation includes, but is not necessarily limited to turbidity meters, pH meters, specific conductance meters, and thermometers.)
- Calibration supplies for all analytical instrumentation, as appropriate

2.3 Equipment Selection and Specifications

The following specifications will be followed:

Cement-Bentonite Grout: Cement-bentonite grout will be a mixture of 95 pounds of Type II Portland Cement, 4 to 6 pound of powdered sodium bentonite, and 5 gallons of potable water. The bentonite must be thoroughly mixed with the water before the cement is added. The cement bentonite grout should have a density of 14 pounds/gallon.

Filter Pack Sand: All filter pack sand will be a clean, well-rounded silica sand, in factory-sealed bags. The sand will conform to the most recent version of the American Water Works Association (AWWA) Standard AWWA/ANSI A100 for water wells. In brief, the standard states that filter pack sand will have an average specific gravity of 2.5 with not more than 1% of the material having a specific gravity less than 2.25, thin, flat or elongated particles shall not exceed 2% of the material, no more than 5% of the material shall be soluble in hydrochloric acid, and the material shall be washed and free of shale, mica, clay, dirt, loam, and organic impurities.

Bentonite: All bentonite will be pure, additive-free bentonite whether it is pellets, chips, or powder.

2.4 Equipment Decontamination

All well materials and drilling equipment which are used to construct a monitoring well or piezometer must be clean and free of any potential contaminants. All well construction materials not certified as decontaminated when delivered will decontaminated by steam cleaning before being installed. Drilling equipment must also be decontaminated, prior to beginning work, by steam cleaning.

All decontamination activities should be done at a specially constructed decontamination pad (or a portable decontamination unit). The decontamination pad should be constructed before any drilling activity begins. The pad should be constructed of HDPE liner material, of sufficient size and strength to allow the drill rig access to the pad, and bermed to contain the generated wastewaters.

At the end of the project day, dispose of all spent decontamination fluids and materials such as the polyethylene sheeting and personal protective equipment in accordance with all applicable municipal, state, and federal regulations.

3.0 Procedures and Guidelines

3.1 Monitoring Well and Piezometer Installation

The specific monitoring well installation methodologies are dependant upon the specific drilling method used. In general, monitoring wells will be constructed through the inside of the drill stem, once the borehole has been advanced to the desired depth.

3.1.1 Borehole Advancement

If the borehole has been drilled to a depth greater than that at which the well is to be set, the borehole must be backfilled with bentonite pellets, bentonite chips and sand, or a bentonite-cement slurry to a depth of approximately one foot below the intended well depth. Approximately one foot of clean sand must be placed on top of the backfill to return the borehole to the proper depth for the well installation.

3.1.2 Installation of Well Screen and Casing

The appropriate lengths of well screen (with bottom cap, or plug, or well point) and casing must be joined watertight and carefully lowered inside the drill stem to the bottom of the borehole. If centering guides are used, they must be placed at intervals around the well casing, beginning no lower than 5 feet above the top of the screen.

3.1.3 Design and Installation of the Filter Pack

After the well screen and casing are installed in the borehole, the filter pack should be installed. The selection of the appropriate filter pack material should be based upon a grain-size analysis of a sample collected from the intended screen interval. The selection of the appropriate filter pack material should be based upon the methodologies presented in "Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells" (US EPA, 1991), the "RCRA Ground Water Monitoring Technical Enforcement Guidance Document" (US EPA, 1986), or any state or local guidance or regulatory documents which are available. In the absence of grain size analyses, the filter pack material should be selected based upon an experienced geologist's best judgement as to the appropriate material.

A filter pack of clean silica sand will be placed around the well screen. Place the filter pack into the borehole at a uniform rate in a manner that will allow even placement of the sand. The drill stem should be raised slowly while the sand is being placed to avoid caving of the borehole walls; the drill stem should never be raised above the top of the filter pack during installation. Using a stainless steel weight on the end of a fiberglass tape, continuously sound the top of the filter pack as it is being installed. The filter pack should extend from the bottom of the borehole to a minimum height of two feet above the top of the well screen. However, this length may be adjusted if it would create the potential for cross-contamination or in the case of shallow water tables.

A finer-grained sand cap should be installed for a minimum of one foot above the filter pack. This height may also be adjusted in the case of shallow water tables, or if it would create the potential for cross-contamination in the well.

3.1.4 Installation of Impermeable Seal

An impermeable seal at least two feet thick must be placed on top of the fine sand cap. The seal may be composed of either bentonite pellets or a bentonite slurry. The pellets must be placed into the borehole in a slow and continuous manner that prevents bridging. This is especially important in deeper monitoring wells where the pellets may have to be emplaced through a considerable depth of standing water in the borehole.

The bentonite slurry should be prepared by mixing 15 pounds of bentonite powder with 7 gallons of water for each one cubic foot of slurry needed. The slurry should be emplaced in the borehole via a tremie pipe. The tremie pipe must be plugged on the bottom and have openings along the sides of the bottom 1-foot length of pipe. This will allow the slurry to be emplaced into the borehole without disturbing the fine sand cap.

Verify the position of the top of the bentonite seal using a weighted tape measure. If all or a portion of the bentonite seal must be emplaced above the water table, hydrate the bentonite with clean water. Allow 30 minutes after adding the water for the bentonite to hydrate.

The thickness of the bentonite seal may be adjusted for wells completed in aquifers with shallow water tables.

3.1.5 Installation of Grout Backfill

Place an annular seal of cement-bentonite grout above the bentonite seal. Install the cement-bentonite grout continuously from the bottom of the annular space to the ground surface through a tremie pipe. The tremie pipe must be plugged on the bottom and have openings along the sides of the bottom one-foot length of pipe. This will allow the grout to be emplaced into the borehole without disturbing the bentonite seal.

3.1.6 Surface Completion

All monitoring wells will be finished at the surface with a concrete pad. The concrete pad should typically be two-feet square and at least 4 inches thick. The concrete should fill the borehole to a depth below the frost line. The pad should be constructed in one continuous pour of concrete. Note that some of the cement-bentonite grout used for the annular seal may have to be removed to install the concrete pad. A survey pin may be installed in the concrete pad before it dries, if necessary.

For monitoring wells that will be completed above-grade, a locking steel protective casing should be installed in the concrete. The protective casing should extend at least three feet into the ground and two feet above ground. For monitoring wells that will be completed flush, a steel roadbox, suitable for traffic loads, with a gasketed cover and drain should be installed.

Properly label each well on the exterior of the locking cap or protective steel casing with a metal stamp indicating the permanent well identifier.

3.1.7 Well Protection Bullards

Guard posts may be installed in high-traffic areas for additional protection. One to four guard posts would be installed around the protective casing, within the edges of the concrete pad. If used, guard posts will be at least 3inches in diameter, concrete-filled steel tubes painted with multiple coats of epoxy-based paint to prevent rust. The guard posts would extend at least two feet below ground and at least three feet above ground.

3.2 Well Development

Monitoring well development may be accomplished by surging and bailing (or pumping), or overpumping. Other methods, such as air jetting, backwashing, or air-lift pumping, should be avoided because these methods introduce fluids into the formation and may have unexpected influences on groundwater quality, if only for a short period of time.

3.2.1 Surging and Bailing

In surging and bailing, a well is developed by alternately surging a short section of the screen with a tight-fitting surge block. Begin by lowering the surge block to the top of the screened interval and swab the well with a pumping action with a typical stroke of 2 to 3 feet. (Begin surging at the top of the well intake to avoid having loosened material from "sand-locking" the surge block.) Do not surge the well too violently to avoid damaging the well screen or the filter pack. Remove the surge block at regular intervals and bail (or pump) the fine material from the well. Proceed with surging throughout the length of the well screen, being careful to avoid hitting the bottom of the well. Check the quality of the bailed water at regular intervals, as described in Section 3.2.3.

In cases where a considerable volume of sediment may initially be drawn into the well, begin surging the well gently in the casing above the well screen. Proceed with surging and bailing to the bottom of the screened interval.

3.2.2 Overpumping

In overpumping, a well is developed by operating a pump in the well at a capacity which greatly exceeds the formation's ability to supply water. The flow velocity into the well during overpumping usually greatly exceeds the flow velocity induced during normal sampling. This increased velocity causes rapid movement of particles from the formation into the well.

Begin developing the well by installing a suitable pump at the bottom of the well. Alternately a surface-mounted pump with a suction hose may be used if the drawdown inside the well will not exceed the pump's available lift. The discharge from the pump should be directed to approved containers. The pump(or intake hose) must be equipped with a backflow-prevention valve to prevent introducing aerated water into the aquifer.

Start the pump and discharge water at the highest practical rate. If the well should run dry, stop the pump and allow the well to recharge. Check the quality of the discharged water at regular intervals as described in Section 3.2.3.

3.2.3 Completing Well Development

During bailing or pumping, measure and record water quality parameters to gauge the degree and effectiveness of development. Typically pH, temperature, specific conductance, and turbidity should be checked at periodic intervals (but at least every well-volume) until these parameters stabilize. The water quality parameters may be considered stable when:

- pH, temperature, and specific conductance of consecutive measurements have relative percent differences (RPD), as defined below, of less than 10%; and,

- the turbidity is 5 NTU or less (applicable only in aquifers with low percentages of fines, and may not be achievable in all situations, but the turbidity should be less than 50 NTUs and should stabilize with an RPD of less than 10%).

However, in no case will development stop before:

- at least 3 well volumes have been removed; and,

- the well has been surged or pumped for at least 30 minutes.

The relative percent difference (RPD) between two measurements (e.g., M1 and M2) is:

$$RPD = \frac{| M1 - M2 |}{(M1 + M2)/2} \times 100\%$$

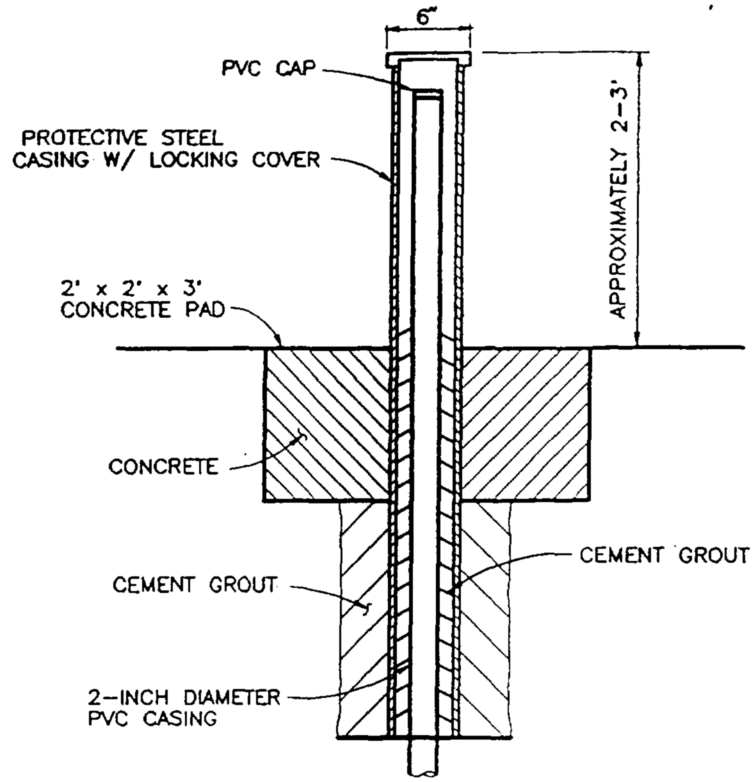
All well development equipment and supplies must be thoroughly decontaminated prior to and between each monitoring well. Place all development water into properly labeled, suitable containers; leave all filled containers in the location specified by the client.

3.3 Monitoring Well Completion Log Forms

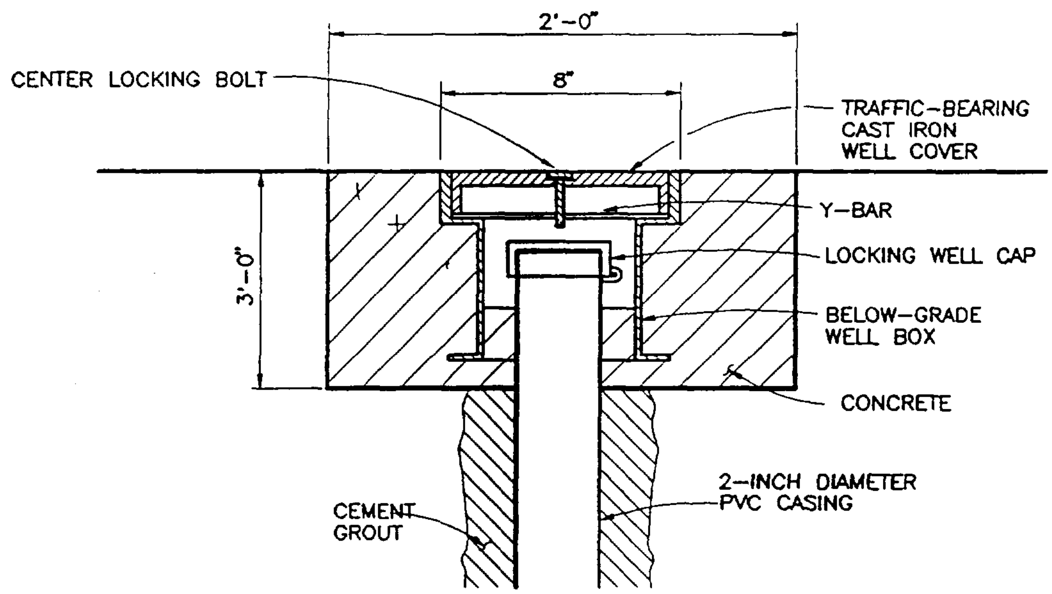
During the installation of a monitoring well, complete records must be kept of quantities and types of all well construction materials used.

A complete geologic log should be kept during the installation of the well. The procedures for completing geologic logs are presented in *Standard Operating Procedure for Geologic Logging Unconsolidated Sediments (SOP #10015).* However, the additional information pertinent to monitoring well installations should be recorded on a separate form. Two Monitoring Well Completion forms are attached to this SOP - one for flush-mount well completions and one for above-grade completions. Whenever a monitoring well is installed, record all appropriate information concerning the quantity of materials used, the type and manufacturer of the materials, the mixtures of grouts or slurries, and any pertinent notes regarding the installation of each well.

After the project is completed, submit a copy of the attached Geologic Soil Boring/Well Completion Log Request Form along with copies of all Monitoring Well Completion forms for final typing. The request form provides information on the types of final logs to be produced, the scale at which to plot the final forms, and notes common to all reports.



ABOVE GRADE WELLHEAD CONSTRUCTION DETAIL



FLUSH TO GRADE WELLHEAD CONSTRUCTION DETAIL

LOUREIRO ENGINEERING ASSOCIATES, P.C.
CONSULTING ENGINEERS
PLAINVILLE, CT

WELLHEAD DETAILS

CKD. BY	APP. BY	SCALE	DATE
LAS/GAB	JJL/JL	NONE	

Standard Operating Procedure
for
Hollow Stem Auger Soil Borings

SOP ID: 10008
Date Initiated: 2/20/94
Revision #004 : 11/20/96

Approved By:

	Name 1	11/20/96 **Date**
	Gail J. Batchelder **Name 2**	11/20/96 **Date**

LOUREIRO ENGINEERING ASSOCIATES

**Standard Operating Procedure
For
Hollow Stem Auger Soil Borings**

1.0 Statement of Purpose

This section discusses procedures for conducting soil borings either for exploration or for the installation of monitoring wells. The LEA representative should be aware that the drillers are responsible for the operation and safety of the drilling rig itself, but should ensure that proper procedures are used with respect to sampling and cleaning of equipment. This document was prepared in accordance with method ASTM D 1452-80. Soil sampling for chemical analysis is covered under "Standard Operating Procedures for Soil Sampling".

2.0 Equipment

2.1 Equipment supplied by LEA that is required for conducting hollow stem auger borings shall include:

- spatula
- distilled water
- hand towels
- portable VOC analyzer (Photovac Microtip® or equivalent)
- polyethylene plastic sheeting
- sample collection jars
- clean disposable gloves
- field documentation
- indelible marker
- three 5-gallon buckets
- alconox detergent, methanol (<10% solution), 10% nitric acid solution, hexane, distilled water
- cooler and cold packs
- graduated cylinder
- analytical balance (accurate to 0.1 gram)
- 500-ml disposable beakers
- EPA Volatile Organic Analysis vial (40 ml)
- field forms
- custody seals and sample labels
- field logbook
- decontamination brushes

- personal protective equipment
- clipboard
- 100-foot measuring tape
- Ziploc plastic bags or equivalent
- chain-of-custody forms

2.2 Drilling Rig

Unless otherwise specified, all soil borings will be conducted using hollow stem auger equipment powered by an appropriate rig. It is the responsibility of the LEA representative to inform the driller prior to entering the site as to the probable depth of borings; probable materials, if known; and desired size of boring. It is the responsibility of the driller to provide the appropriate rig and augers in good working order considering the above factors.

2.3 Water

2.3.1 Water is occasionally required to maintain the stability of the boring. If water is used, the source(s), quality, and volume(s) will be recorded in the drilling log.

2.3.2 No other drilling fluid or compressed air, may be used without specific authorization from the Project Manager.

2.4 Central Auger Opening Plug

In order to maintain clean, accurate samples, no hollow stem auger drilling may be conducted without the use of the central plug bit. The driller must be aware of this prior to entering the site.

2.5 Cleaning and Decontamination

2.5.1 Prior to conducting a boring, the LEA representative will ensure that all necessary equipment is clean and decontaminated, including the rig, all augers and bits, samplers, brushes, and any other tools or equipment. Decontamination procedures may vary slightly from those presented below, dependent upon the particular types of contaminants encountered.

2.5.2 A section of 5-mil (minimum) plastic sheeting shall be cut of sufficient size to underlie the decontamination area to contain any discharge of decontamination solutions.

2.5.3 The following solutions shall be prepared and placed in 500-ml laboratory squirt bottles: less than 10% methanol solution; 10% nitric acid solution; 100% hexane solution; and distilled deionized (DI) water. A fifth solution of phosphate-free detergent and tap water (approximately 2.5 gallons) shall be prepared in a five-gallon bucket.

2.5.4 All loose debris shall be removed from the augers and spatulas into an empty 5-gallon bucket or plastic sheeting using a stiff bristled brush.

2.5.5 The order of decontamination solutions is as follows:

1) Detergent Scrub
2) DI Water Rinse
3) Hexane Rinse
4) DI Water Rinse
5) 10% Nitric Acid Rinse
6) DI Water Rinse
7) Methanol Rinse (<10% solution)
8) Air Dry

2.5.6 Wrap each piece of decontaminated sampling equipment in aluminum foil to maintain cleanliness.

2.5.7 An alternative to the procedure described above requires that the equipment be cleaned using a high-pressure wash and steam cleaning. Alternative methods of cleaning may be more appropriate for an individual piece of equipment for site conditions based upon a knowledge of site contaminants, and may be used at the discretion of the LEA representative. Section 2.5.8 provides additional information on management of potentially contaminated fluids and materials. in an area constructed to contain spent decontamination fluid and debris (plastic sheeting bermed with timber is usually sufficient).

2.5.8 At the end of the project day, all used equipment shall be decontaminated. All spent decontamination solutions will be handled and disposed of in accordance with all applicable municipal, state and federal regulations.

2.6 Utilities

2.6.1 Notify the appropriate "one call" utility notification service (e.g. Call Before You Dig) at least three working days prior to commencing operations on a site. The locations of all proposed borings must be clearly marked in the field prior to notification.

2.6.2 Particularly upon larger private sites, consult with the Owner or other person knowledgeable about the site as to locations of potential private or abandoned utilities and locate these prior to beginning work. Upon the discretion of the Project Manager, a pipe locator can also be used to assist in locating utilities.

2.6.3 Note that OSHA may have additional requirements for location of utilities.

2.6.4 All efforts to locate underground utilities should be properly documented in the field log book prior to onset of the work scheduled.

2.7 OSHA

The Foreman or Supervisor of the drilling crew shall be the Competent Person as required by OSHA for all of their work. However, this does not relieve the LEA representative from bringing to his or her attention conditions which may be unsafe or present a hazard to the drilling crew, the general public, or other workers on the site. The LEA representative will be responsible for ensuring that LEA activities are performed in accordance with the site-specific Health & Safety Plan.

2.8 Public Health

Since drilling equipment may be used elsewhere to construct other types of wells, including wells for private water supplies, all equipment, including the rig, augers, and tools must be thoroughly decontaminated prior to leaving the site. On sites with known contamination, testing may be required to confirm adequacy of cleaning.

2.9 VOC Monitoring

2.9.1 A portable volatile organic compound (VOC) analyzer shall be available on site and shall be used to screen all cuttings and fluids (if any) removed from the hole.

2.9.2 Since, in general, it cannot be presumed that a site is clean, all cuttings and/or fluids which show a reading on the VOC analyzer, above background shall be containerized or drummed, as appropriate, on site. Section 3.6 provides additional information on management of potentially contaminated fluids and materials.

3.0 Procedure

3.1 Site Preparation

3.1.1 A sufficient area shall be cordoned off to restrict access to the work area. This area shall be termed an "Exclusion Zone".

3.1.2 An equipment decontamination area shall be assembled, as described in Section 2.5, within the exclusion zone.

3.1.3 The area immediately surrounding the proposed borehole and the back portion of the rig (including the tires) shall be covered with 5-mil plastic sheeting. A hole of sufficient diameter shall be cut from the center of the plastic sheeting to facilitate auger advancement.

3.1.4 All personal protective equipment shall donned.

3.2 Rig Operation

3.2.1 Rig operation is the responsibility of the drilling crew Foreman or Supervisor.

3.2.2 The representative of LEA will bring to the attention of rig operator the requirements of sampling, health and safety, utility restrictions, decontamination procedures, and well construction specifications.

3.2.3 The rig should be inspected upon arrival on-site to insure: that it is in good working order; that all required equipment and supplies are present; and that the rig is free of loose debris, oil leaks, or defective equipment. Only when the representative of LEA is satisfied that these requirements have been met will the drilling crew be allowed to decontaminate the rig and begin work.

3.3 Sampling

3.3.1 All shallow soil sampling, unless otherwise specified by the site specific work plan, shall be conducted via a split-spoon (or similar) sampling device operating through hollow stem augers.

3.3.2 Hollow stem augers and central auger plug shall be advanced to the depth of the sampling interval.

3.3.3 After removing the central auger plug, the split-spoon sampler will be lowered into the augers. It will then be driven 18 to 24 inches into the soil using a 140-pound hammer with a fall of three feet. A heavier hammer may be used in exceptionally dense materials provided its use is recorded in the boring log. The driller and the LEA representative will count and record the blows for each six-inch increment.

3.3.4 The split spoon shall be opened and immediately scanned using the VOC analyzer using the approach described in Section 3.4.7.

3.3.5 The LEA representative will record on the boring log as a minimum: description of the material in the sampler, blow counts, depth, VOC analyzer reading, material gradation using the Burmeister system, color, moisture, and density.

3.3.6 Prior to reuse, the sampling device shall be decontaminated using the procedures described in Section 2.5.

3.3.7 Soil samples collected for archive purposes shall be placed into 4-ounce clear soil jars and labeled with the boring number, depth, blow counts, and commission number.

3.3.8 The procedures for collection of soil samples for chemical analysis are described in the *Standard Operating Procedure for Soil Sampling*.

3.4 Field Analysis

3.4.1 The probe used to detect VOCs shall be either a Photovac Microtip® photoionization detector or a Foxboro OVA® flame ionization detector or equivalent and calibrated in accordance with the instructions provided by its manufacturer. Calibration shall be performed prior to each sampling event and checked after each day of sampling.

3.4.2 The following procedure shall be used to obtain readings of the VOCs present in a soil sample:

1) Obtain an aliquot of soil (approximately 50 grams) from the split spoon and place it into a Ziploc® plastic bag or equivalent and sealed.

2) Agitate the sample, assuring that all soil aggregates are broken, for two minutes.

3) Carefully break the seal of the bag enough to insert the VOC probe.

4) Record the maximum reading obtained on the appropriate forms, as described in Section 3.5.

3.5 Field Documentation

3.5.1 The following general information shall be recorded in the field log book and/or on the appropriate field form(s):

- Site identification
- LEA commission number
- Site location
- Name of recorder
- Identification of borings
- Collection method
- Date and time of collection
- Types of sample containers used, sample identification numbers and QA/QC sample identification
- Field analysis method(s)
- Field observations on sampling event
- Name of collector
- Climatic conditions, including air temperature
- Chronological events of the day
- QA/QC data
- Name of drilling firm
- Location of boring on site insufficient detail to relocate boring at a future time (include sketch)

3.5.2 The following information shall be recorded on the boring log:

- Project name, location, and LEA commission number
- Borehole number, borehole diameter, boring location, drilling method, contractor, groundwater observations, logger's name and date
- Depth below grade, sample I.D. number, duplicate numbers, VOC analyzer reading, number of blows required for a six-inch penetration of a two-inch diameter split spoon using a 140-pound hammer, rig behavior (i.e. drilling effort, etc.)
- A complete sample description, including as a minimum: depth, material size gradation using the Burmeister system, color, moisture,

and density. Should a well be constructed in a borehole, a complete well schematic shall be drawn and accurately labeled
- Use of water, including source(s) and quantity

3.5.3 The following information shall be recorded on the Field Quality Review Checklist:

- Reviewer's name, date, and LEA commission number
- Review of all necessary site activities and field forms
- Statement of corrective actions for deficiencies

3.5.4 The Field Instrument & Quality Assurance Record shall include the following information:

- Client's name, location, LEA commission number, date
- Instrument make, model, and type
- Calibration readings
- Calibration/filtration lot numbers
- Field personnel and signature

3.6 Disposal of Potentially Contaminated Materials

Potentially contaminated cuttings or fluids, as indicated by knowledge of the site, discoloration, VOC analyzer readings, or other evidence, shall be containerized on the site pending sampling and determination of hazardous waste status.

3.7 Refusal

Refusal is defined as failure to penetrate with a split-spoon sampler more than one (1) inch with 100 blows using a 140-pound hammer.

3.8 Bedrock

The term "bedrock" will not be used in a boring log or other description unless a minimum of three (3) feet of bedrock core is recovered using an appropriate core drill, and in the opinion of a competent geologist, the core is representative of bedrock in the region.

3.9 Boring Abandonment

3.9.1 If the boring is not to be used for other purposes (i.e. monitoring well, soil vapor probe, soil vapor extraction well, etc.), it shall be abandoned.

3.9.2 The boring shall be filled and sealed, as the augers are withdrawn, with neat cement grout or high density bentonite clay grout.

3.9.3 Excess cuttings shall be containerized and sampled before disposal.

3.9.4 In paved areas, the upper three feet of the borehole shall be filled with sand, up to two inches below the existing grade, to allow for repairing of the pavement.

3.9.5 Pavement shall be repaired using cold patch asphalt filler or concrete.

4.0 Other

Depending on the specific site, other considerations may be applicable. Consult the OSHA regulations, applicable RCRA or CERCLA regulations, and the site-specific work plan for details.

Standard Operating Procedure
for
Sediment Sampling in Shallow Rivers and Ponds

SOP ID: 10009
Date Initiated: 11/03/94

Approved By: ______________________ 11/3/94
Name 1 **Date**

Gail T. Batchelder 11/3/94
Name 2 **Date**

LEA

LOUREIRO ENGINEERING ASSOCIATES

Standard Operating Procedure For

Sediment Sampling

1.0 Statement of Purpose

This document discusses procedures for collection of sediment samples for laboratory analysis. Methods for quality assurance/quality control requirements are included in a separate SOP. The procedures outlined in this document are in accordance with the EPA document Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846). These procedures may vary slightly according to the needs of specific projects.

2.0 Equipment

2.1 Equipment required for the collection of soil samples shall include:

- 2.1.1 Stainless steel spatula (spoon, scoop, trowel, etc.)
- 2.1.2 Distilled water
- 2.1.3 Hand towels
- 2.1.4 Polyethylene plastic sheeting
- 2.1.5 Sample collection jars
- 2.1.7 Clean disposable gloves
- 2.1.8 Field documentation
- 2.1.9 Indelible marker
- 2.1.10 Cooler, cold packs and maximum/minimum thermometer
- 2.1.11 Custody seals and sample labels

2.2 Cleaning and Decontamination

2.2.1 Prior to collecting sediment samples, the LEA representative will ensure that all necessary sampling equipment is clean and decontaminated according to the site specific work plan or collection method SOPs.

2.2.2 Upon completion of all sampling requirements and prior to leaving the site, all equipment used for sampling shall be cleaned and decontaminated. All generated decontamination fluids shall be disposed of in accordance with the site specific work plan and all municipal, state and federal requirements.

3.0 Sampling Protocols

3.1 Preliminary Sampling Procedures

3.1.1 Sample Bottles

3.1.1.1 A Laboratory Request Form shall be completed and submitted to the laboratory with following information:

- Project and LEA Commission Number
- Date of submittal and date needed
- Quantity of sample locations and sample points at each location
- Type(s) of samples
- Analytes, detection limits and QA/QC needed
- Cooler(s) required
- Number of Chain-of-Custody forms requested

3.1.1.2 Check bottles against Laboratory Request Form for completeness. The bottles should also be checked for damage and cleanliness. Confirm with laboratory personnel the adequacy of the preservatives used.

3.1.1.3 Label all bottles prior to sampling with the information and check for accuracy. This step may also be performed in the field prior to sample collection.

3.1.1.4 The total number of sample sets shall be increased by 10% to allow for possible breakage during transport to sites or other contingencies (minimum: one additional sample bottle set per event).

3.1.1.5 A cooler with adequate ice or cold packs should be obtained from the laboratory to insure that the collected samples remain at 4°C during transport. Packing material should also be obtained to insure against breakage during transport.

3.1.2 Site Preparation

3.1.2.1 Polyethylene sheeting shall be laid on the ground in the vicinity of the sample collection location.

3.1.2.2 Decontaminated spatulas shall be wrapped in aluminum foil and placed on the table. Prelabeled sample bottles shall be placed in a convenient location and in order of sample collection.

3.2 Sampling Procedures

3.2.1 All personal protective equipment (PPE) should be donned and maintained in accordance with the site specific work plan or health and safety plan during all sampling procedures. In the event that no PPE has been specified for a particular sampling event, disposable latex gloves should be donned, as a minimum, during all sampling procedures.

3.2.2 In order to obtain representative samples, it is important to minimize physical agitation of sediments. If it is necessary to stand in the surface water body (e.g. river) to collect sediment samples, the samples must be collected upstream of the disturbed area. Samples should be collected from the most downstream location, moving upstream for subsequent samples.

3.2.3 The particular sediment sampling device (i.e. spatula) shall be placed on the polyethylene sheeting.

3.2.4 Utilizing a decontaminated stainless steel spatula, sediment shall be transferred directly into a prelabeled sampling container. Care should be taken to completely fill the sample container. Large void spaces within the container shall be minimized by packing, <u>not</u> agitation.

3.2.5 Wipe the rim of the sample container with a clean paper towel to remove excess solids which would prevent adequate sealing of the sample container and seal the container.

3.2.6 Affix a custody seal, noting the date and time of collection across the cap/bottle interface and on the sample label. Place and secure sample within cooler and complete all sample collection documentation.

3.3 Post-Sampling Procedures

3.3.1 Upon completion of all sampling procedures for a particular site, secure the lid of the cooler using packaging tape with the Chain-Of-Custody inside.

3.3.2 Should the laboratory be local, transport the samples directly to the laboratory and present to the sample manager. The representative of LEA should witness the verification of the Chain-Of-Custody and obtain a carbon copy for filing in the project notebook.

3.3.3 Should the laboratory be distant, arrange for transport with a reputable carrier service. The cooler and samples shall be secured for transport, and all mailing documentation secured onto the top of the cooler. Unless otherwise specified, delivery shall be overnight. A request for confirmation of acceptance should be made to the carrier at the time of pick-up.

3.4 Documentation

3.4.1 The following general information will be recorded in the field log book:

- Site identification, LEA Commission number
- Site location
- Name of recorder
- Identification of borings
- Collection method
- Date and time of collection.
- Types of sample containers used, sample identification numbers and QA/QC sample identification
- Preservative(s) used
- Parameters requested for analysis
- Field analysis method(s)
- Field observations on sampling event
- Name of collector
- Climatic conditions including air temperature
- Internal temperature of field and shipping (refrigerated) containers
- Chronological events of the day
- QA/QC data
- Sampling location(s) on the site sufficient to relocate at a future time (include sketch)

3.4.2 The following information will be recorded on the sample collection data sheet:

- Client name, location and LEA commission number
- Sample identification number
- Date and time of collection
- Depth from which sample was obtained

3.4.3 The following information will be recorded on the Field Quality Review Checklist:

- Reviewer's name, date, and LEA commission number
- Review of all necessary site activities and field forms
- Statement of corrective actions for deficiencies

3.4.4 The following information will be recorded on the chain-of-custody record:

- Client's name and location
- Sample identification and/or number
- Date and time of collection
- Container type, number, size
- Preservative used
- Signature of collector
- Signatures of persons involved in the chain of possession
- Analyses to be performed

3.4.5 The following information will be provided on the sample label using an indelible pen:

- Sample identification number
- Name of collector
- Date and time of collection
- Place of collection
- Parameter(s) requested (if space permits)

Standard Operating Procedure
for
Shallow Surface Water Sampling and Flow Measurement

SOP ID: 10010
Date Initiated: 11/03/94

Approved By: ____________________ 11/3/94
Name 1 **Date**

Gail S. Batchelder 11/3/94
Name 2 **Date**

LEA

LOUREIRO ENGINEERING ASSOCIATES

**Standard Operating Procedure
For
Shallow Surface Water Sampling and Flow Measurement**

1.0 Statement of Purpose

This document describes procedures to be followed for collecting surface water samples and obtaining flow measurements. Quality assurance/quality control requirements are covered in a separate SOP.

2.0 Equipment

2.1 Equipment required for the collection and field analysis of liquid samples will include:

2.1.1 Clean glass, polyethylene, stainless steel or fluorocarbon resin sampling container (typical containers include beakers, jugs, sealable bottles and jars, and long-handled scoops)
2.1.2 Polyethylene plastic sheeting
2.1.3 Distilled water
2.1.4 Hand towels
2.1.5 Peristaltic pump and polyethylene tubing
2.1.6 Weirs, flumes, submerged orifices and/or current meters
2.1.7 Clean disposable gloves
2.1.8 Field documentation
2.1.9 Indelible marker
2.1.10 Sample labels and custody seals
2.1.11 Cooler, cold packs and maximum/minimum thermometer

3.0 Flow Measurement

3.1 Weirs, Flumes, and Orifices

3.1.1 Weirs, flumes, and submerged orifices are devices that restrict stream flow to a well-defined cross-sectional area. Flow velocity and discharge are calculated using cross-sectional area and head differences in standard equations. For very small flows, velocity and discharge are measured directly by collecting the flow in a bucket over a specified period.

3.1.2 Stage gauging is required to calculate flows using weirs, flumes, or orifices. Staff gauges may be mounted on the weir, flume, or dam. Hook, wire, or chain gauges connected to graduated disk or automatic recording devices are commonly used. Stilling wells are necessary where stage gauging techniques other than staff gauges are used, especially if long-term or continuous stage measurements are planned.

3.1.3 The steps taken to measure flows depend on the type and manufacturer of the weir, flume, or orifice. Standard calibration tables and coefficients are identified for the specific type of device used. Stage measurements are made using an appropriate technique, and the applicable tables and coefficients are used to calculate the flow.

3.1.4 Field measurements are recorded in the logbook with the date and time of measurement.

3.2 Current Meters

3.2.1 Current meters are mechanical or electrical devices that measure flow velocity for a well-defined area. Mechanical flow meters contain screws or turbines that, when fully submerged, rotate at a speed proportional to that of the flowing fluid. Flow velocity is determined by comparing the shaft rotation rate to a calibration table provided by the manufacturer. Rotation rate may be obtained either by a direct-reading meter or by continuous recording on chart paper. Electrical current meters consist of a bulb-shaped chamber housing two electrodes. Fluid flow through this chamber causes a slight electromagnetic disturbance that causes a small voltage potential between the electrodes. The electronic circuitry makes this voltage proportional to flow velocity and allows a direct readout of velocity.

3.2.2 Specific steps in using current meters are as follows:

- The current meter is assembled and tested according to the manufacturer's instructions.

- The stream is partitioned using bridge railings or a tag line divided into measurement segments. Visual estimation of relative flow velocity and channel geometry, augmented by a few depth measurements, is used to select flow measurement locations and depths. No more than 10 percent of the total stream discharge should flow through any one measurement compartment.

- A temporary staff gauge is installed at the starting point to record the stream stage. The flow velocity is recorded at that point, taking care not to disturb bottom sediments.

- Stream depth and current meter flow velocity data are recorded at each station.

- After the appropriate data for the last measurement station are obtained, the ending stream stage is recorded.

4.0 Sample Collection

A new piece of polyethylene plastic will be placed on the ground in the vicinity of the surface water sampling location. Sampling equipment will be placed on the polyethylene sheet, never on the ground.

4.1 Manual Sampling

4.1.1 Surface water samples are taken manually by submerging a clean glass, stainless steel, or fluorocarbon resin container into the water body and pulling it back out. Samples may be taken at depth with a covered bottle that can be removed with a tripline. The most common sampler types are beakers, sealable bottles and jars, pond samplers, and weighted bottle samplers. Pond samplers have a fixed or telescoping pole attached to the sample container. Weighted bottle samplers are lowered below water surface, where the attached bottle is opened, allowed to fill, and pulled out of the water. When retrieved, the bottle is tightly capped and removed from the sampler assembly. Specific types of weighted bottle samplers include dissolved oxygen, Kemmerer, or Van Dorn, and are acceptable in most instances.

4.1.2 A sample is taken with the following specific steps:

- The location and desired depth for water sampling are selected. Generally, the most representative samples are obtained from mid-channel at one-half of the stream depth in well-mixed streams.

- The sample site is approached from downstream in a manner that avoids disturbance of bottom sediments as much as possible. The sample bottle is gently submerged to just below the water surface with the mouth pointed upstream and the bottle tilted slightly downstream. Bubbles and floating materials should be prevented from entering the bottle.

- For weighted bottle samplers, the assembly is slowly lowered to the desired depth. The bottle stopper is unseated with a sharp tug and the bottle is allowed to fill until bubbles stop rising to the surface. In no case shall preserved sample bottles be used as the sampling device to collect water samples from the surface water body.

- When the bottle is full, it is gently removed from the water. If sample transfer is required, it should be performed at this time.

4.2 Mechanical Sampling

4.2.1 Mechanical surface water sampling involves a peristaltic pump that conveys water through heavy-walled tubing to a container. The tubing must be flexible and made of a non-reactive material such as Tygon or Teflon®; Teflon® is usually selected when oil and grease are present. Medical-grade or silicon tubing may be satisfactory in some cases, depending on the constituents to be analyzed. An external power source may be required, but many peristaltic pumps are reequipped with batteries.

4.2.2 In some situations, it may be desirable or necessary to locate the container between the water intake and the pump connection. The peristaltic pump may then be used as a vacuum pump. The vacuum pump method cannot be used for samples on which analyses for volatile organic compounds (VOCs) will be conducted, as it very effectively strips VOCs from water.

4.2.3 When sampling at depths or in fast currents, the inlet tubing is weighted or attached to some stationary object such as a bridge piling or a pole stuck in bottom sediments. Weighing the tubing can cause stretching and reduce the inside tubing diameter, which reduces pump capacity. Insertion of a pole into bottom sediments adds particulates to the water column. Water sampling should not commence until particulates have settled.

4.2.4 The following steps are taken in mechanical surface water sampling:

- The inlet and outlet tubing is connected to the appropriate ports located on the pump housing. The interior of the housing is checked to be sure that the pump tubing is properly connected.

- The intake end of the inlet tubing is placed at the selected sample location, and the discharge end of the outlet tubing is placed in the sample container. The sample is pumped until the sample container is full. The pump may be allowed to run for a period of time to flush the sampling device before collecting a sample.

- When the pump is stopped, the discharge end of the outlet tube is removed from the sample container. The sample container is capped and labeled.

- If the peristaltic pump is being used as a vacuum pump, the inlet tubing at the top of the collection container is detached first. This prevents back-siphoning when the vacuum is released. The vacuum is released by slowly admitting air as the inlet tubing is disconnected to prevent blow-back and reduce aeration of the sample. After the vacuum is released, the sample is transferred to a sample bottle.

- Peristaltic pumps are cleaned and decontaminated by disposing of the interior and exterior tubing. Tubing is difficult to completely clean, particularly of oils and greases.

4.3 Do <u>not</u> re-use sampling equipment (sample devices, tubing, sampling vials, etc.). Equipment shall either be disposable or shall be returned to the office and decontaminated for future use.

4.4 If requested, analysis for field parameters, such as pH, specific conductance, and/or temperature, should be performed at each surface water sampling location, or at a minimum, at the most upstream and downstream sampling locations. However, it is not necessary to perform replicate sampling for these parameters, unless specifically requested in the site-specific Quality Assurance/Quality Control Plan.

4.5 Samples shall be collected in the following order into pre-labeled sample containers:

- Volatile organic compounds (VOC)
- Purgeable Organic Carbon (POC)
- Purgeable Organic Halogens (POX)
- Total Organic Halogens (TOX)
- Total Organic Carbon (TOC)
- Extractable Organics (semi-volatile)
- Metals
- Phenols
- Cyanide
- Chloride and Sulfate
- Turbidity
- Nitrate and Ammonia
- Radionuclides

4.6 Samples collected for VOC and semi-volatile analysis shall be free of any air bubbles and inverted upon filling. Bacterial samples shall be collected using dedicated gloves; taking care not to allow anything to touch the inside of the sampling container.

4.7 Samples collected for metals analysis shall be filtered in the field through 0.45 micron (maximum) membrane filter under negative pressure.

4.8 In situations where replicate samples shall be required, care shall be taken to ensure that each sample collected is independent.

4.9 In some situations, inorganic parameters may be sampled directly from a peristaltic pump after evacuation of at least three volumes of water in the length of tubing.

5.0 Field Documentation

5.1 Field documentation will include at a minimum, a Chain-of-custody form, field log notebook, Field Sample Record Form, Daily Field Report, Field Quality Review Checklist, and Laboratory Request Form. Sample labels and sample seals shall be used for proper sample identification.

5.2 Sample labels will be sufficiently durable to withstand immersion for 48 hours without detaching and to withstand normal handling. The information provided shall be legible at all times.

5.2.1 The following information will be provided on the sample label using an indelible pen:

- Sample identification number
- Name of collector
- Date and time of collection
- Place of collection
- Parameter(s) requested (if space permits)
- Internal temperature of shipping container at time sample was placed

5.2.2 Sample seals will be secured on each sample bottle following the collection of each sample. Sample seals may only be removed by laboratory personnel.

5.3 A field logbook will be used to log all pertinent information with an indelible pen. The following information shall be provided:

- Identification of location
- Flow measurement technique
- Sample identification numbers
- Sample withdrawal procedure/equipment

- Date and time of collection
- Results of field measurements (pH, specific conductance, and/or temperature) as appropriate.
- Types of sample containers used and sample identification numbers
- Preservative(s) used
- Parameters requested for analysis
- Field observations on day of sampling event
- Name of collector
- Climatic conditions including air temperature
- Internal temperature of field and shipping (refrigerated) containers

5.4 A Field Sampling Record, which summarizes the day's samples, will be completed. The Field Sampling Record will include at a minimum the following information:

- Identification of sample location and number
- Date and time of collection
- Name of collector
- Sample number

5.4.1 The chain-of-custody record will include the following information:

- Company's name and location
- Date and time of collection
- Sample number
- Container type, number, size
- Preservative used
- Signature of collector
- Signatures of persons involved in the chain of possession
- Analyses to be performed

5.4.2 The Field Quality Review Checklist will assure the completeness of the sampling round and include the following information:

- Reviewer's name, date, and LEA commission number
- Review of all necessary site activities and field forms
- Statement of corrective actions for deficiencies

Standard Operating Procedure
for
Geoprobe® Probing and Sampling

SOP ID: 10011
Date Initiated: 11/10/94
Revision #002: 11/20/96

Approved By:

Name 1 — Date 11/20/96

Gail L. Batchelder — 11/20/96
Name 2 — Date

LOUREIRO ENGINEERING ASSOCIATES

Standard Operating Procedure
for
Geoprobe® Probing and Sampling

1.0 Statement of Purpose

The objective of this procedure is to collect a discrete soil sample at depth using Geoprobe® probing and sampling methodologies and to recover the sample for visual inspection and/or chemical analysis. Procedures for soil sampling for chemical analysis are included in *Standard Operating Procedures for Soil Sampling.*

2.0 Background

2.1 Definitions

Geoprobe® *: A vehicle-mounted, hydraulically-powered, soil probing machine that utilizes static force and percussion to advance small diameter sampling tools into the subsurface for collecting soil core, soil gas, or groundwater samples.

* (Geoprobe is a registered trademark of Kejr Engineering, Inc., Salina, Kansas.)

Large Bore Sampler: A 24-inch long x 1-3/8-inch diameter piston-type soil sampler capable of recovering a discrete sample that measures up to 320 ml in volume, in the form of a 22-inch x 1-1/16-inch core contained inside a removable liner.

Liner: A 24-inch long x 1-1/8-inch diameter removable/replaceable, thin-walled tube inserted inside the Large Bore Sampler body for the purpose of containing and storing soil samples. Liner materials include brass, stainless steel, Teflon®, and clear plastic (either PETG or cellulose acetate butyrate).

2.2 Discussion

In this procedure, the assembled Large Bore Sampler is connected to the leading end of a Geoprobe® brand probe rod and driven into the subsurface using a Geoprobe® machine. Additional probe rods are connected in succession to advance the sampler to depth. The sampler remains sealed (closed) by a piston tip as it is being driven. The piston is held in place by a reverse-threaded stop-pin at the trailing end of the sampler. When the sampler tip has reached the top of the desired sampling interval, a series of extension rods, sufficient to reach depth, are coupled together and lowered down the inside diameter of the probe rods. The extension rods are then rotated clock-wise (using a handle). The male threads on the leading end of the extension rods engage the female threads on the top end of the stop-pin, and the pin is removed. After the extension rods and stop-pin have been removed, the tool string is advanced an additional 24 inches. The piston is displaced inside the sampler body by the soil as the sample is cut. To recover the sample, the sampler is recovered from the hole and the liner containing the soil sample is removed.

3.0 Required Equipment

The following equipment is required to recover soil core samples using the Geoprobe® Large Bore Sampler and driving system. Sample liners for the Large Bore Sampler are available in four different materials. Liner materials should be selected based on sampling purpose, analytical parameters, and data quality objectives.

Large Bore Sampler Parts	Part Number
STD Piston Stop-pin, O-ring	AT-63, 63R
LB Cutting Shoe	AT-660
LB Drive Head	AT-661
LB Sample Tube	AT-662
LB Piston Tip	AT-663
LB Piston Rod	AT-664
LB Clear Plastic Liner	AT-665
LB Brass Liner	AT-666
LB Stainless Steel Liner	AT-667
LB Teflon® Liner	AT-668
LB Cutting Shoe Wrench	AT-669
Vinyl End Caps	AT-641
Teflon® Tape	AT-640T

Geoprobe® Tools	Part Number
Probe Rod (3 foot)	AT-10B
Probe Rod (2 foot)	AT-10B
Probe Rod (1 foot)	AT-10B
Drive Cap	AT-11B
Pull Cap	AT-12B
Extension Rod	AT-67
Extension Rod Coupler	AT-68
Extension Rod Handle	AT-69
Optional	**Part Number**
LB Manual Extruder	AT-659K
Extension Rod Jig	GS-469
LB Pre-Probe	AT-146B
Additional Tools	
Vise Grips	
Open Ended Wrench (3/8-inch)	
1-inch or Adjustable Wrench	

4.0 Procedures

4.1 Utilities Clearance

4.1.1 Notify the appropriate "one call" utility notification service (e.g. Call Before You Dig) at least three working days prior to commencing operations on a site. The locations of all proposed borings must be clearly marked in the field prior to notification.

4.1.2 Particularly upon larger private sites, consult with the owner or other person knowledgeable about the site as to locations of potential private or abandoned utilities and locate these prior to beginning work. Upon the discretion of the project manager, a pipe locator can also be used to assist in locating utilities.

4.1.3 Note that OSHA may have additional requirements for location of utilities.

4.1.4 All efforts to locate underground utilities should be properly documented in the field log book prior to onset of the work scheduled.

4.2 OSHA

The foreman or supervisor of the drilling crew shall be the Competent Person as required by OSHA for all of their work. However, this does not relieve the LEA representative from bringing to his or her attention conditions which may be unsafe or present a hazard to the drilling crew, the general public, or other workers on the site. The LEA representative is responsible for ensuring that LEA activities are conducted in accordance with the site-specific Health and Safety Plan.

4.3 Site Preparation

4.3.1 A sufficient area shall be cordoned off to restrict access to the work area. This area shall be termed an "Exclusion Zone".

4.3.2 An equipment decontamination area shall be assembled as described in Section 4.11 within the exclusion zone.

4.3.3 The area immediately surrounding the proposed borehole and the back portion of the rig (including the tires) shall be covered with 5 mil plastic sheeting. A hole of sufficient diameter shall be cut from the center of the plastic sheeting to facilitate auger advancement.

4.3.4 All personal protective equipment shall donned.

4.4 Assembly

4.4.1 Install a new AT-63R)-ring into the O-ring groove on the AT-63 Stop-pin.

4.4.2 Seat the pre-flared end of the LB Liner (AT-665, -666, -667, or -668) over the interior end of the AT-660 Cutting Shoe. It should fit snugly.

4.4.3 Insert the liner into either end of the AT-662 Sample Tube and screw the cutting shoe and liner into place. If excessive resistance is encountered during this task, it may be necessary to use the AT-669 LB Shoe Wrench. Place the wrench on the ground and position the sampler assembly with the shoe end down so that the recessed notch on the cutting shoe aligns with the pin in the socket of the wrench. Push down on the sample tube while turning it, until the cutting shoe is threaded tightly into place.

4.4.4 Screw the AT-664 Piston Rod into the AT-663 Piston Tip. Insert the piston tip and rod into the sample tube from the end opposite the cutting shoe. Push and rotate the rod until the tip is seated completely into the cutting shoe.

4.4.5 Screw the AT-661 Drive Head onto the top end of the sample tube, aligning the piston rod through the center bore.

4.4.6 Screw the reverse-threaded AT-63 Stop-pin in the top of the drive head and turn it **counter-clockwise** with a 3/8-inch wrench until tight. Hold the drive head in place with a 1-inch or adjustable wrench while completing this task to assure that the drive head stays completely seated. The assembly is now complete.

4.5 Pilot Hole

A pilot hole is appropriate when the surface to be penetrated contains gravel, asphalt, hard sands, or rubble. Pre-probing can prevent unnecessary wear on the sampling tools. A Large Bore Pre-Probe (AT-146B) may be used for this purpose. The pilot hole should be made only to a depth above the sampling interval. Where surface pavements are present, a hole may be drilled with the Geoprobe® using a Drill Steel (AT-32, -33, -34, or -35, depending upon the thickness of the pavement), tipped with a 1.5-inch diameter Carbide Drill Bit (AT-36) prior to probing. For pavements in excess of 6 inches, the use of compressed air to remove cuttings is recommended.

4.6 Driving

4.6.1 Attach an AT-106B 1-foot Probe Rod to the assembled sampler and an AT-11B Drive Cap to the probe rod. Position the assembly for driving into the subsurface.

4.6.2 Drive the assembly into the subsurface until the drive head of the LB sample tube is just above the ground surface.

4.6.3 Remove the drive cap and the 1-foot probe rod. Secure the drive head with a 1-inch or adjustable wrench and re-tighten the stop-pin with a 3/8-inch wrench.

4.6.4 Attach an AT-105B 2-foot Probe Rod and a drive cap, and continue to drive the sampler into the ground. Attach AT-10B 3-foot Probe Rods in succession until the leading end of the sampler reaches the top of the desired sampling interval.

4.7 Preparing to Sample

4.7.1 When sampling depth has been reached, position the Geoprobe® machine away from the top of the probe rod to allow room to work.

4.7.2 Insert an AT-67 Extension Rod down the inside diameter of the probe rods. Hold onto it and place an AT-68 Extension Rod Coupler on the top threads of the extension rod (the down-hole end of the leading extension rod should remain uncovered). Attach another extension rod to the coupler and lower the jointed rods down-hole.

4.7.3 Couple additional extension rods together in the same fashion as in Step 2. Use the same number of extension rods as there are probe rods in the ground. The leading extension rod must reach the stop-pin at the top of the sampler assembly. When coupling extension rods together, you may opt to use the GW-469 Extension Rod Jig to hold the down-hole extension rods while adding additional rods.

4.7.4 When the leading extension rod has reached the stop-pin down-hole, attach the AT-69 Extension Rod Handle to the top extension rod.

4.7.5 Turn the handle **clockwise** (right-handed) until the stop-pin detaches from the threads on the drive head. Pull up lightly on the extension rods during this procedure to check thread engagement.

4.7.6 Remove the extension rods and uncouple the sections as each joint is pulled from the hole. The Extension Rod Jig may be used to hold the rod couplers in place as the top extension rods are removed.

4.7.7 The stop-pin should be attached to the bottom of the last extension rod upon removal. Inspect it for damage. Once the stop-pin has been removed, the sampler is ready to be re-driven to collect a sample.

4.8 Sample Collection

4.8.1 Reposition the Geoprobe® machine over the probe rods, adding an additional probe rod to the tool string if necessary. Make a mark on the probe rod 24 inches above the ground surface (this is the distance the tool string will be advanced).

4.8.2 Attach a drive cap to the probe rod and drive the tool string and sampler another 24 inches. Use of the Geoprobe®'s hammer function during sample collection may increase the sample recovery in certain formations. Do not over-drive the sampler.

4.9 Retrieval

4.9.1 Remove the drive cap on the top probe rod and attach an AT-12B Pull Cap. Lower the probe shell and close the hammer latch over the pull ap.

4.9.2 With the Geoprobe® foot firmly on the ground, pull the tool string out of the hole. Stop when the top (drive head) of the sampler is about 12 inches above the ground surface.

4.9.3 Because the piston tip and rod have been displaced inside the sample tube, the piston rod now extends into the 2-foot probe rod section. In loose soils, the 2-foot probe rod and sampler may be recovered as one piece by using the foot control to lift the sampler the remaining distance out of the hole.

4.9.4 If excessive resistance is encountered while attempting to lift the sampler and probe rod out of the hole using the foot control, unscrew the drive head from the sampler and remove it with the probe rod, the piston rod. and the piston tip. Replace the drive head onto the sampler and attach a pull cap to it. Lower the probe shell and close the hammer latch over the pull cap and pull the sampler the remaining distance out of the hole with the probe machine foot firmly on the ground.

4.10 Sample Recovery

4.10.1 Detach the 2-foot probe rod if it has not been done previously.

4.10.2 Unscrew the cutting shoe using the AT-669 LB Cutting Shoe Wrench, if necessary. Pull the cutting shoe out with the liner attached. If the liner doesn't slide out readily with the cutting shoe, take off the drive head and push down on the side wall of the liner. The liner and sample should slide out easily.

4.11 Core Liner Capping

4.11.1 The ends of the liners can be capped off using the AT-641 Vinyl End Cap for further storage or transportation. A black end cap should be used at the bottom (down end) of the sample core and a red end cap at the top (up end) of the core.

4.11.2 On brass, stainless steel, and Teflon® liners, cover the end of the sample tube with AT-640T Teflon® Tape before placing the end caps on the liner. The tape should be smoothed out and pressed over the end of the soil core so as to minimize headspace. However, care should be taken not to stretch and, therefore, thin the Teflon® tape.

4.12 Sample Removal

4.12.1 Large Bore Clear Plastic and Teflon® Liners can be slit open easily with a utility knife for the samples to be analyzed or placed in appropriate containers.

4.12.2 Large Bore Brass and Stainless Steel liners separate into four 6-inch sections. The AT-659K Large Bore Manual Extruder may be used to push the soil cores out of the liner sections for analysis or for transfer to other containers.

4.12.3 The procedures for collection of soil samples for chemical analysis are described in the *Standard Operating Procedure for Soil Sampling.*

4.12.4 Soil samples collected for archive purposes shall be placed into 4-ounce clear soil jars and labeled with boring numbers, depth, and commission number.

4.13 Equipment Decontamination and Cleaning

4.13.1 Prior to conducting a boring, the LEA representative will ensure that all necessary equipment is clean and decontaminated, including the rig, all augers and probing equipment, samplers, brushes, and any other tools or equipment. Decontamination procedures may vary slightly from those presented below, dependent upon the particular types of contaminants encountered.

4.13.2 A section of 5-mil (minimum) plastic sheeting shall be cut of sufficient size to underlie the decontamination area to contain any discharge of decontamination solutions.

4.13.3 The following solutions shall be prepared and placed in 500-ml laboratory squirt bottles: methanol solution (less than 10%); 10% nitric acid solution; 100% hexane solution; and distilled deionized (DI) water. A fifth solution of phosphate-free detergent and tap water (approximately 2.5 gallons) shall be prepared in a five-gallon bucket. Only those solutions required for site-specific conditions will be used at a given site, as specified in the site-specific work plan.

4.13.4 All loose debris shall be removed from the augers and spatulas into an empty 5-gallon bucket or plastic sheeting using a stiff bristled brush.

4.13.5 The order of decontamination solutions is as follows:

1) Detergent Scrub
2) DI Water Rinse
3) Hexane Rinse
4) DI Water Rinse
5) 10% Nitric Acid Rinse
6) DI Water Rinse
7) Methanol Rinse (<10% solution)
8) Air Dry

4.13.6 Each piece of decontaminated sampling equipment will be wrapped in aluminum foil to maintain cleanliness.

4.13.7 An alternative to the procedure described above requires that the equipment be cleaned using a high-pressure wash and steam cleaning in an area constructed to contain spent decontamination fluid and debris (plastic sheeting bermed with timber is usually sufficient). Alternative methods of cleaning may be more appropriate for an individual piece of equipment for site conditions based upon a knowledge of site contaminants, and may be used at the discretion of the LEA representative. Section 5.4 provides additional information on management of potentially contaminated fluids and materials.

4.13.8 At the end of the project day, all used equipment shall be decontaminated. All spent decontamination solutions will be handled and disposed of in accordance with all applicable municipal, state and federal regulations.

4.14 VOC Monitoring

4.14.1 A portable volatile organic compound (VOC) analyzer shall be available on site and shall be used to screen all cuttings and fluids (if any) removed from the hole.

4.14.2 Since, in general, it cannot be presumed that there is no contamination at a given site, all cuttings and/or fluids which show a reading on the VOC analyzer that is above background shall be containerized or drummed, as appropriate, on site. Additional information on management of potentially contaminated fluids and materials is presented in Section 5.4.

5.0 Sample Collection and Documentation

5.1 Sample collection following removal from borehole.

5.1.1 The sample tube shall be opened by the LEA representative and immediately scanned using the VOC analyzer using the approach described in Section 5.2.

5.1.2 The LEA representative will record on the boring log at a minimum: description of the material in the sampler, depth, VOC analyzer reading, material size gradation using the Burmeister system, color, moisture, and relative density.

5.1.3 Prior to reuse, the sampler shall be decontaminated using the procedures described in Section 4.13.

5.1.4 Soil samples collected for archival purposes shall be placed into 4-ounce clear soil jars and labeled with the boring number, depth, and commission number.

5.1.5 The procedures for collection of soil samples for chemical analysis are described in the *Standard Operating Procedure for Soil Sampling*.

5.2 Field Analysis

5.2.1 The following procedure shall be used to obtain readings of the VOCs present in a soil sample:

1) Obtain an aliquot of soil (approximately 50 grams) from the split spoon and placed into a Ziploc™ plastic bag or equivalent and sealed.

2) Agitate the sample, assuring that all soil aggregates are broken, for two minutes.

3) Carefully break the seal of the bag enough to insert the VOC probe.

4) Record the maximum reading obtained on the appropriate forms, as described in Section 5.3.

5.3 Field Documentation

5.3.1 The following general information shall be recorded in the field log book:

- Site identification
- LEA commission number
- Site location
- Name of recorder
- Identification of borings
- Collection method
- Date and time of collection
- Types of sample containers used, sample identification numbers and QA/QC sample identification
- Field analysis method(s)
- Field observations on sampling event
- Name of collector
- Climatic conditions, including air temperature
- Chronological events of the day
- QA/QC data
- Name of drilling firm
- Location of boring on site insufficient detail to relocate boring at a future time (include sketch)

5.3.2 The following information shall be recorded on the boring log:

- Project name, location, and LEA commission number
- Borehole number, borehole diameter, boring location, drilling method, contractor, groundwater observations, logger's name and date
- Depth below grade, sample I.D. number, duplicate numbers, VOC analyzer reading, rig behavior (i.e. drilling effort, etc.)
- A complete sample description, including as a minimum: depth, material size gradation using the Burmeister system, color, moisture, and density. Should a well be constructed in a borehole, a complete well schematic shall be drawn and accurately labeled
- Use of water, including source(s) and quantity

5.3.3 The following information shall be recorded on the Field Quality Review Checklist:

- Reviewer's name, date, and LEA commission number
- Review of all necessary site activities and field forms
- Statement of corrective actions for deficiencies

5.3.4 The Field Instrument & Quality Assurance Record shall include the following information:

- Client's name, location, LEA commission number, date
- Instrument make, model, and type
- Calibration readings
- Calibration/filtration lot numbers
- Field personnel and signature

5.4 Disposal of Potentially Contaminated Materials

Potentially contaminated cuttings or fluids, as indicated by knowledge of the site, discoloration, VOC analyzer readings, or other evidence, shall be containerized on-site pending sampling and determination of hazardous waste status.

5.5 Refusal

Refusal is defined as failure to penetrate the subsurface materials to any greater depth using the maximum reasonable pressure limits of the Geoprobe® machine.

5.6 Bedrock

The term "bedrock" will not be used in a boring log or other description of subsurface materials that have been collected using the Geoprobe® machine, since a confirmational core cannot be collected.

5.7 Boring Abandonment

5.7.1 If the boring is not to be used for other purposes (i.e. monitoring well, soil vapor probe, soil vapor extraction well, etc.) it shall be abandoned.

5.7.2 The boring shall be filled and sealed with neat cement grout or high density bentonite clay grout as soon as the tools are withdrawn from the borehole.

5.7.3 Excess cuttings shall be containerized and sampled before disposal.

5.7.4 In paved areas, the upper three feet of the borehole shall be filled, up to two inches below the existing grade, with sand to allow for repairing of the pavement.

5.7.5 Pavement shall be repaired using cold patch asphalt filler or concrete.

6.0 Other

Depending on the specific site, other considerations may be applicable. Consult the OSHA regulations, applicable RCRA or CERCLA regulations, and the site-specific work plan for details.

7.0 References

Geoprobe® Systems, August 1993, "1993-04 Equipment and Tools Catalog".

Standard Operating Procedure
for
Sample Management
Associated with the LEA Analytical Laboratory

SOP ID: 10012
Date Initiated: January 17, 1995
Revision: #001: 11/20/96

Approved By:

	Name 1	11/20/96 **Date**
	Name 2	11/20/96 **Date**

LOUREIRO ENGINEERING ASSOCIATES

Standard Operating Procedure
for
Sample Management
Associated with the LEA Analytical Laboratory

1.0 Statement of Purpose

This document discusses procedures for collection, handling and transport of soil, water and vapor samples for analysis by the Loureiro Engineering Associates (LEA) Analytical Laboratory. The procedures outlined in this document are a condensed version of several other SOPs. This SOP is intended to serve as a quick reference for the field sampler. Quality Assurance Quality Control (QA/QC) criteria for collection of blank samples is included in this SOP.

2.0 General Sampling Guidelines for all Sample Types (i.e. soil, water, vapor)

- Define sampling objectives with Project Manager.
- Obtain sampling equipment.
- Ensure that all necessary sampling equipment is properly decontaminated.
- Obtain necessary sample containers (40 ml vials, Tedlar bags®) and labels. Include enough containers for specified QA/QC samples.
- Obtain a cooler with adequate ice or cold packs to ensure that the collected samples remain at about 4°C during transport. Packing material should also be obtained to provide protection against breakage.
- Obtain necessary personal protective equipment (PPE) as specified in the site specific work plan or Health and Safety Plan. In the event that no PPE has been specified for a particular sampling event, disposable gloves should be used as a minimum, during all sampling collection activities.
- Obtain all the necessary paper work including the site specific work plan, Health and Safety Plan, applicable SOPs, field forms, chain-of-custody and sample documentation forms.

2.1 Soil Samples

2.1.1 Refer to the appropriate soil sampling SOP for details.

2.1.2 Calibrate the portable field balance according to the manufacturer's specifications.

2.1.3 Place a clean, dry 40 ml vial on the balance and tare (zero) the balance and vial.

2.1.4 Using a decontaminated stainless steel spatula transfer approximately 5 grams of soil into the 40 ml vial. Due to rapid volatilization time is more critical than the exact mass of the soil (4.0 g - 6.0 g is acceptable).

2.1.5 Record the mass of the soil.

2.1.6 Immediately transfer the 40 ml vial from the balance to the 30 ml measuring block. Add distilled water so that the bottom of the meniscus coincides with the top of the block.

2.1.7 Cap the vial immediately.

2.1.8 Store the vial cap side down in a cooler (maintained at about 4°C) containing ice or cold packs.

2.1.9 Complete the internal chain-of-custody along with all appropriate sample documentation forms.

2.2 Water Samples

2.2.1 Refer to the SOP on *Liquid Sample Collection and Field Analysis* for details.

2.2.2 In order to ensure that the groundwater sample is representative of the formation, it is important to minimize physical alteration or chemical contamination of the sample during the withdrawal process.

2.2.3 Place a properly labelled 40 ml vial in a 30 ml measuring block.

2.2.4 Using the appropriate decontaminated sampling equipment, withdraw the water sample from its origin and transfer 30 ml of sample into the pre-labelled 40 ml vial. The bottom of the meniscus is to be lined up with the top of the measuring block.

2.2.4.1 Due to volatilization, avoid excessive agitation, air bubbles, etc. during the sample transfer process.

2.2.5 Immediately cap the 40 ml vial.

2.2.6 Store the vial cap side down in a cooler (maintained at about 4°C) containing ice or cold packs.

2.3 Vapor Samples

2.3.1 Refer to the appropriate Vapor Collection SOP for details.

2.3.2 Attach the soil vapor sampler and clean Tygon® tubing to the appropriate vapor sampling port.

2.3.3 Purge the system for 2 minutes.

2.3.4 Attach a clean Tedlar® bag to the discharge end of the soil vapor sampler and purge the Tedlar® bag by filling and emptying it three times.

2.3.5 Fill the Tedlar® bag a fourth time, close the valve on the bag, remove the bag from the system.

2.3.6 Label the Tedlar® bag with the appropriate sampling information.

2.3.7 Complete all necessary sample documentation forms.

2.3.8 Store the samples in a cool, dry place. Avoid leaving the samples in the sun or other sources of heat.

3.0 QA/QC Procedures for Soil, Water and Vapor Samples

3.1 Refer to the *Quality Assurance/Quality Control Measures for Field Activities* SOP for details.

3.2 All QA/QC samples are collected following the same procedure described for the appropriate matrix.

3.3 All QA/QC samples shall be properly documented.

3.4 At the conclusion of each sampling day, a quality control review shall be conducted using the Field Quality Review Checklist and the Daily Field Report.

3.5 The following QA/QC samples are to be collected.

3.5.1 Trip Blank

3.5.1.1 Contaminated trip blanks may indicate contamination of the samples during the field trip or shipment to the lab, cross contamination between the samples, contaminated sample vials or improper handling.

3.5.1.2 Trip blanks are prepared using analyte-free deionized water prior to the sampling event. They are placed in the same type of bottle or container as the sample(s) to be collected for which they serve as a blank, and are carried in the same shipping container as that sample or samples.

3.5.1.3 <u>Trip blanks shall be used with volatile organic samples only.</u>

3.5.1.4 One trip blank shall be included per sample bottle/preservation technique/analysis procedure per sampling day, or one every twenty samples collected (if more than twenty samples are collected during the day).

3.5.2 Field Blank/Equipment Blank

3.5.2.1 The purpose of a field blank/equipment blank is to determine if decontamination procedures were adequate.

3.5.2.2 A field blank/equipment blank is prepared by running analyte-free deionized water through sample collection equipment (bailers, pumps, filters, split spoon) and placing it in the appropriate sample containers for analysis. The field blank is treated exactly as another independent sample, and thus has its own associated bailer, filter apparatus, and other expendable equipment.

3.5.2.3 Field blanks shall be used when sampling surface water, groundwater, soil sediments and soils.

3.5.2.4 One field blank shall be collected for each sample bottle/preservation technique/analysis procedure per matrix per sampling event.

4.0 Sample Transport

4.1 All soil and water samples collected in 40 ml VOA vials to be submitted to the LEA Analytical Laboratory for analysis:

4.1.1 Must be stored with the cap of the vial facing downward.
4.1.2 Must be transported in a cooler with ice.
4.1.3 Must accompany a Chain-of-Custody.

4.2 Vapor samples collected in Tedlar® bags to be submitted to the LEA Analytical Laboratory for analysis:

4.2.1 Must be submitted to laboratory personnel immediately upon arrival.
4.2.2 Must be kept away from sources of heat (i.e. sun, etc.).
4.2.3 Must be accompanied by a Chain-of-Custody.

5.0 If the Samples are Brought in During Regular Working Hours

5.1 Submit the samples along with the "ORIGINAL" LEA Internal Chain-of-Custody to the laboratory. Sign, date and record the time of relinquishing the samples. Laboratory personnel will check the samples against the Chain-of-Custody then sign, date and record the time of receiving the samples.

5.2 The "ORIGINAL" Chain-of-Custody will be returned to the sampler. The lab will maintain a "COPY" of the Chain-of-Custody.

5.3 Submit a "COPY" of the Chain-of-Custody to the LEA Data Manager.

6.0 If the Samples are Brought in After Hours

6.1 The samples should be placed in the refrigerator in the lab (40 ml EPA VOA vials should be stored with the CAP SIDE DOWN to prevent any loss of VOCs through the cap).

6.2 Sign, date and record the time of relinquishing the samples.

6.3 Leave the "ORIGINAL" LEA Internal Chain-of-Custody under the magnet on the refrigerator door.

6.4 Submit a "COPY" of the Chain-of-Custody to the LEA Data Manager.

6.5 After the samples are signed in by the laboratory, the original Chain-of-Custody will be returned to the field sampling personnel. The lab will maintain a copy of the Chain-of-Custody.

6.6 Follow up the next day to confirm that the sample was properly received, and the analysis properly completed.

Standard Operating Procedure
for
Soil Vapor Surveying

SOP ID:	**10014**
Date Initiated:	**9/1/92**
Revision #002:	**3/22/96**

Approved By:

Name 1	3/22/96 Date
Name 2	3/22/96 Date

LEA

LOUREIRO ENGINEERING ASSOCIATES

Standard Operating Procedure for Soil Vapor Surveying

1.0 Statement of Purpose

1.1 Scope

This Standard Operating Procedures (SOP) describes the methods and procedures to be followed in conducting a soil vapor survey. It provides the procedures for installing soil vapor sampling points and the methodology for sampling these points.

1.2 Rationale for Selection of Probe Location

Prior to performing the soil vapor survey, the location of the soil vapor points should be preliminarily located based on a grid system. These gridded points should be placed on a figure to take out to the site. Based on field results, the grid locations can be adjusted to define the extent of detected constituents. The grid may also be modified to reflect site-specific features.

Similarly, modifications to the sampling procedure can be made based on field results. For example, if no constituents are detected, then field blanks between each sample could be eliminated until constituents are detected. The project manager should approve all changes to the procedures.

One soil vapor probe will be installed as a reference probe. This probe will be left in place for the length of the soil vapor survey for the purpose of collecting repeat measurements as discussed in Section 4.0.

2.0 Soil Vapor Probe Installation

2.1 Equipment that is required for installation and sampling shall include:

1. ¼" diameter shield points
2. Interconnecting nipples
3. Soil vapor sampler (including pumps, vacuum gauges and air flowmeters)
4. Vacuum desiccator
5. Tedlar® bags
6. Rotary hammer drills

7. Rubber mallet
8. Screw drivers, wrenches, and channel lock pliers
9. Pairs of lineman's gloves and ear protection
10. Utility knives
11. Extension cords
12. Purge pump with Tygon® tubing
13. Flat cleaning brushes
14. Rolls of Teflon tape
15. Ground fault circuit interrupters
16. Generator (if required)
17. Road boxes, concrete, bentonite grout (permanent installations)
18. Stop watch

2.2 Probe Installation Procedure

2.2.1 Safety Precautions

Locate the sampling point. If the location has not been checked for utilities by an authorized site official or "Call-Before-You-Dig", make arrangements to have this done before you proceed. Allow a minimum of 3 days for Call-Before-You-Dig to clearly mark all utility locations. Confirm that the site has been clearly marked. If subsurface metal objects are likely to be present, a metal detector should be utilized for location identification.

To protect against electric shock when using the hammer drill, a Ground Fault Circuit Interrupter (GFCI) will be utilized. This device will automatically shut down the electric hammer drill when it senses a short.

As an added precaution when drilling in areas where there is a potential for drilling into live electrical wires, the hammer drill operator will wear insulated lineman's gloves to prevent the passage of an electric current up the drill and into the operator's body.

Head Protection " Hard Hat?

Eye and ear protection is required while operating the hammer drill. It is advised that hand protection also be worn when manipulating the soil augers on the electric hammer drill.

2.2.2 Drill Procedures

When restrictive layers or pavement surfaces are present, drill a pilot hole using a 1½" diameter solid auger prior to the insertion of the soil vapor sampling probe. After attaching the auger, select the "hammer/drill" mode on the drill to commence augering.

Grasp the drill tightly while augering to offset the torque generated by the auger. Periodically retract the auger from the borehole to clean the cuttings from the flights. Once pilot hole augering has been completed, insert the stainless steel shield point and drive from four to six inches into the undisturbed soil (i.e. to the desired depth) using a rubber mallet. Mold a ball of clay or tight soil around the shaft where it intersects the ground surface to seal off the borehole. (Figure 1)

Use dedicated probes for each sampling location. Alternatively, flush the vapor probe for 2-5 minutes with ambient air and collect a blank sample (ambient air) for on-site screening with the gas chromatograph. Dedicated probes should be used if the gas chromatograph is not available at the site.

2.3 Sampling Procedures

The procedure described below will be followed when low level contamination is expected (less than 10 ppm). A vacuum desiccator will be used when heavier contamination is suspected. A portable total VOC analyzer equipped with a PID or FID detector will be used to provide guidance.

2.3.1 Low-Contamination Levels Soil Vapor Surveying

Attach the tubing from the soil vapor sampler to the probe shaft. The soil vapor sampler includes a pump, two flowmeters for measuring high and low range flow rates, a vacuum gauge, and a needle valve for adjusting the flow. **The flowmeter readings should be converted to flow units using the conversion table provided with each instrument.**

Purge at least three times the volume of gas contained within the probe, tubing and soil vapor sampler. Do not purge excessively to avoid pulling air from the surface. Measure the air flow by observing the air flowmeter and using a stop watch. This can be measured by filling and emptying a Tedlar® bag a set number of times (say three times). Do not fill the Tedlar® bag to firmness at any time.

After sampling adjust and record the flow and vacuum on the soil vapor sampling equipment. Repeat this procedure at three different flow rates (maximum achievable, low, and mid-range). This information is useful in determining field intrinsic air permeabilities.

Once samples from all desired depths have been collected from the sample location, disconnect the soil vapor sampling equipment and remove the probe from the ground.

Leave soil vapor sampling pump on at high air flow between sampling locations to purge the instrument and tubing.

Move to the next soil vapor sampling location. After installing the next vapor probe (dedicated) in accordance with Section 2.2, collect an equipment blank prior to sampling at the new location. The equipment blank will be collected from the purged soil vapor sampling equipment using either a Tedlar® bag or a GC syringe. If the results of analysis of this blank shows no contamination, then the new soil vapor sampling location can be sampled as discussed above. If contamination is detected, continue purging and collecting equipment banks until no contamination remains.

2.3.2 High-contamination Levels Soil Vapor Surveying

These procedures will be followed when highly contaminated vapor samples (greater than 10 ppm) are suspected.

Use the vacuum desiccator to collect the air samples to avoid contamination of the air sampling equipment. Check local air quality surrounding the sample collection point to ensure safe working conditions. Attach the vacuum desiccator to the vapor probe using a 3/16" ID x 3/8" OD Tygon® tubing. Attach the tubing to the vacuum desiccator. Keep tube length as short as possible.

Attach 1/4" ID x 3/8" OD Tygon® tubing to the Tedlar® bag and the other end to the inside of the vacuum desiccator. Place the Tedlar® bag into the vacuum desiccator. Next, attach a length of 3/16" ID x 3/8" OD Tygon® tubing, approximately 4" long, from the vacuum desiccator to the air sampling equipment intake.

Turn on the air sampling equipment. The air sampling equipment should be set to pump at a maximum rate.

Purge system by filling and emptying the Tedlar® bag three times. Do not fill bag to firmness at any time. This is done to prevent stress cracks from forming and destroying the Tedlar® bag. Every time the bag is filled you must open the desiccator, remove the Tedlar® bag and then empty the bag. Afterward, place the bag into the vacuum desiccator again and continue these steps until the system is purged.

Collect the sample by filling the Tedlar® bag, being careful not to overfill.

Close the valve on the Tedlar® bag and remove the bag from the desiccator. Label bag and log in the field report.

→ cannot be found at SOPs start #10003

3.0 Sample Analysis

Samples will be analyzed for volatile organic compounds (VOCs) with the LEA portable GC. The LEA portable GC will be operated in accordance with the LEA SOP for the Portable Gas Chromatograph (SOP #10002). Meters will be properly calibrated at the start of each day and periodically throughout the day in accordance with LEA SOPs or manufacturer specifications.

4.0 Quality Assurance/Quality Control (QA/QC)

To preserve sample integrity, all sampling equipment will be stored away from volatile organic vapors when not in use. To reduce the risk of cross-contamination, all equipment which comes into contact with the sample will be thoroughly purged or will be dedicated equipment.

Additional QA/QC checks include ambient air blanks and equipment blanks. A sampling location is selected which provides typical levels of contaminants observed at the site and repeat measurements at the reference probe installations (a minimum of twice daily) are performed in order to assure reproducibility of the data. Soil vapor data are recorded on customized data sheets and carefully reviewed on a daily basis.

Standard Operating Procedure
for
Geologic Logging of Unconsolidated Sedimentary Materials

SOP ID: 10015
Date Initiated: 12/27/94
Revision #001: 11/20/96

Approved By:

Name 1	11/20/96 **Date**
Gail T. Batchelder **Name 2**	11/20/96 **Date**

LEA

LOUREIRO ENGINEERING ASSOCIATES

Standard Operating Procedure
for
Geologic Logging of Unconsolidated Sedimentary Materials

1.0 Statement of Purpose

This document presents the methods and procedures used to describe unconsolidated sedimentary materials for geological purposes in a uniform and consistent manner. It includes procedures for properly recording the observations by providing guidelines for completing boring logs and submitting those logs for computer entry. This Standard Operating Procedure (SOP) refers only to geologic logging of soils and sediments (including artificial fill and other man-made deposits) and specifically is not intended to describe logging of soils or sediments for geotechnical or other engineering purposes. Although the SOP presents a system for describing sediments, it is not intended to be a definitive reference for classifying sedimentary materials, nor is it intended to replace experience or training. Individuals using this SOP should be trained and competent in field methodologies and geologic logging prior to commencing field activities.

2.0 Collection of Unconsolidated Soil/Sediment Samples

2.1 Equipment required for the geologic logging of soil/sediment samples shall include the following items:

- Tape measure or scale
- Hand lens
- Color chart
- Grain-size comparator
- Field forms
- Indelible marker(s)
- Small table
- Field Book
- Clipboard

2.2 Sample Collection

Samples of soil and unconsolidated sedimentary materials will be collected in general accordance with the SOPs for Soil Sampling (SOP #10006), Hand Auger Borings (SOP #10003), Hollow Stem Auger Soil Borings (SOP #10008), and Geoprobe® Probing and Sampling (SOP #10011). Those SOPs include procedures for decontamination of equipment required for sample collection, as well as providing the methodologies for sample collection and documentation.

3.0 Descriptions of Unconsolidated Sedimentary Materials

3.1 General Sediment Description Guidelines

For the purposes of geologically logging unconsolidated soils and sedimentary materials, a Modified Burmister method of description and classification should be used. The Modified Burmister Sediment Classification System (or simply, Burmister System) is intended as a rapid field method for identifying and classifying sediments. The system is based upon visual identification of the generalized grain-size distribution and description of the physical characteristics of the sample.

A Burmister System description is comprised of three parts: a color descriptor; a grain-size descriptor; and modifier(s).

The color descriptor indicates the overall color or colors of the wet sample. The descriptor consists of a color name or names and (if possible) the color code from a standard color reference (for example, a Munsell® Color Chart).

The grain-size description indicates the predominant grain size in the sample, as well as the relative percentages of other grain sizes present.

Modifiers are used to further describe the geologic character of the sample. Modifiers may include descriptions of moisture content, sorting, sphericity, angularity, sedimentary structures or other pertinent information.

3.1.1 Color Description

The color of the wet sediment should be determined with reference to a standard color comparator (for example, a Munsell® Color Chart) for rocks or sediment. The included color descriptor should contain both the color name and, when a color comparator is used, the appropriate hue-chroma value code, for example "Reddish brown (5YR 4/4)". The color of a sample should always be gauged when the sample is wet, or it should be noted otherwise.

3.1.2 Predominant Grain-Size Description

The first step in describing a sediment sample is visually estimating the size range and percentage of the various grain sizes in the sample. Reference should be made to standard geologic comparators for assessment of the grain size(s).

The primary grain-size descriptor indicates the predominant grain size, as judged visually, of the sample. The descriptor is always capitalized and underlined. Possible descriptors include: CLAY, SILT, SAND, GRAVEL (GRANULES, PEBBLES, COBBLES, and BOULDERS). These correspond to the standard Wentworth size-classification scheme used for describing sediments for geologic purposes. Size classifications for CLAY through GRAVEL are presented in Table 1. The descriptor should also include an indication of the relative size range of the sample within the predominant grain size (for example, "fine-to-medium sand", "coarse sand", etc). Although Table 1 includes divisions of the silt category, this is applicable only to sediment samples analyzed by pipette or hydrometer and cannot be distinguished in the field.

The presence of other grain sizes, in addition to the predominant material is also included in the grain-size descriptor. Appropriate grain sizes are the same as for the predominant grain size of the material (clay, silt, etc.), however only the initial letter of the word is capitalized. The description should also include an indication of the relative amount of the minor components. Appropriate indicators for the relative percentages present are provided in Table 2.

It is generally not considered possible to visually distinguish between clay and silt. Estimation of the silt/clay content of a sample should be based upon the plastic properties of the sample. The plastic properties of the sample may be estimated by taking an approximately 1 cubic centimeter ball of the sediment and attempting to roll a thread of the material between the palms of the hand. The minimum size of the thread which may be rolled may be compared to the values presented in Table 3 and the plasticity estimated. A comparison of the minimum thread diameter which may be formed with the information presented in Table 3 provides an approximate silt/clay content estimate for sand-silt-clay sediments and composite clay sediments.

3.1.3 Modifiers

Various modifiers may be added to the basic sediment description to further describe the geologic character of the sample.

For sand or coarser-sized material, the relative degree of sorting, the sphericity, and angularity should also be recorded. Sorting may be visually estimated. Sphericity and angularity, however, should be made with reference to an accepted comparator. A chart illustrating various degrees of sphericity and angularity is attached as Figure 1.

The mineralogy of the sample should also be recorded. Reference should be made to the relative percentages, grain size(s), and sphericity of the mineral particles (especially where it differs significantly from that of the predominant grain-size material).

Other information which should be recorded for each sample includes an estimate of the density and cohesiveness of the sample (made from blow counts where applicable, or other specific instrumentation where appropriate), the relative moisture content of the sample, visible sedimentary structures, and any odors or staining noticeable during logging. Tables 3 and 4 present appropriate terms for describing the plasticity, density, and cohesiveness of sediment samples.

Especially important is an indication that a specific portion of the material may represent "sluff" or material collapsed from the borehole walls.

3.2 Written Sediment Descriptions

The written sediment description may be made as either an unabbreviated or an abbreviated description. Both methods should relate the same information, however the abbreviated description is better suited for field use.

In an unabbreviated description, all of the words of the description should be written out in their entirety. The descriptor should include pertinent information regarding the sample's size gradation, consistency, color, and relative grain size, as described previously. The color descriptor should precede the primary sediment component name, while additional details such as the plasticity, mineralogy, visible sedimentary structures, etc., should follow the sediment component name.

An example of an unabbreviated description is:

> **Red-brown (5YR 4/4), fine to coarse SAND, little fine Gravel, little Silt, moist, moderately well sorted, low sphericity, Gravel waterworn, Sand subangular, micaceous.**

Since the Burmister system is intended to provide a means for describing uniform sediments, three "special" cases should be addressed.

First, the Burmister system is intended only to describe the sediment. Where a genetic classification of the material is significant, it should be added as a separate statement at the end of the description. For example:

> **Olive gray (5Y 4/2), coarse to fine SAND, some fine Gravel, little Silt, moist, poorly sorted, sub-rounded to angular, dense. TILL.**

A genetic classification should only be used when the origin of the material is very clear and not simply a field interpretation of possible depositional environment.

Second, in the case where the sediment sample is heterogenous (for example, a varved silt and clay), each component should be described individually, and reference should be made to the relative percentages of each component and to the interlayering. For example:

> **Soft, reddish-brown (5YR 3/4), CLAY and SILT, alternately layered, medium to high overall plasticity. Layers: CLAY layers, 3/8" to 5/8" thick, comprise 60%± of sample. SILT layers, 1/8" to 3/8" thick, comprise 40%± of sample. VARVED CLAY and SILT.**

Third, when one material grades uniformly into a distinct sediment type, the individual components should be described separately and the gradation noted. For example:

> **Soft, reddish-brown (5YR 3/4), CLAY, medium overall plasticity, grading into soft, reddish-brown (5YR 4/4), SILT, trace Clay, low overall plasticity.**

In the abbreviated sediment descriptions, the sample information is presented in a manner analogous to that for the unabbreviated description substituting standard abbreviations for specific portions of the text. Abbreviations for the identifying terms in the Burmister system are presented in Tables 2, 3, and 4. Mineralogic and geologic abbreviations may be found in standard geologic and mineralogic texts and field manuals. Except for the use of abbreviations, the abbreviated description is completely analogous to the unabbreviated description.

For the sake of consistency in describing unconsolidated sedimentary materials, the description should follow the order and general definitions presented in Table 5.

4.0 Recording Descriptions

4.1 Geologic Boring Logs

Attached to this SOP is a copy of LEA's standard geologic boring log form. This log should be completed for each boring that is completed. The heading information is self-explanatory. The body of the log contains space for information for each sampled interval in the boring. The following information should be recorded:

Depth Interval	The upper and lower depths from which the sample was collected.
Sample No.	The sample number, as obtained from LEA Data Management, assigned to this sample.
Recovery	The length of the recovered sample and the length of the sampler (in consistent units). The percent recovery will be calculated by the geologic logging program.
Blows/6"	The number of blow counts per 6" interval for the sample. Alternately, the downhole pressure or other pertinent information regarding the required drilling or sampling force.
Sample Description	The sample description using the guidelines and order presented in Section 3.0 and Table 5.
PID/FID	The headspace reading from a PID or FID in ppm.

The comments section of the form should be used to record general observations regarding drilling conditions, backfilling of the borehole, or other pertinent information regarding drilling the borehole.

4.2 Computer Data Entry

After a project is completed, copies of the Geologic Boring Log forms should be submitted for computer data entry. A completed copy of the Geologic Soil Boring/well Completion Log Request Form should be attached to the log forms; a copy of the request form is attached to this SOP.

TABLE I
Wentworth Size Classification System

US Standard Sieve Sizes	Millimeters	Microns	Phi (ϕ)	Wentworth Size Classification	
	4096	4,096,000	-20		
Use Wire Squares	1024	1,024,000	-10	Boulder	G
	256	256,000	-8	Cobble	R
	64	64,000	-6		
	16	16,000	-4	Pebble	A
5	4	4,000	-2		V
6	3.36	3,360	-1.75		
7	2.83	2,830	-1.50	Granule	E
8	2.38	2,380	-1.25		L
10	2.0	2,000	-1.00		
12	1.68	1,680	-0.75		
14	1.41	1,410	-0.50	Very Coarse Sand	
16	1.19	1,190	-0.25		
18	1.00	1,000	0.00		
20	0.84	840	0.25		
25	0.71	710	0.50	Coarse Sand	
30	0.59	590	0.75		
35	0.50	500	1.00		S
40	0.42	420	1.25		A
45	0.35	350	1.50	Medium Sand	
50	0.30	300	1.75		N
60	0.25	250	2.00		D
70	0.210	210	2.25		
80	0.177	177	2.50	Fine Sand	
100	0.149	149	2.75		
120	0.125	125	3.00		
140	0.105	105	3.25		
170	0.088	88	3.50	Very Fine Sand	
200	0.074	74	3.75		
230	0.0625	62.5	4.00		
270	0.053	53	4.25		
325	0.044	44	4.50	Coarse Silt	
	0.037	37	4.75		
	0.031	31	5.0	Medium Silt	
	0.0156	15.6	6.0	Fine Silt	M
	0.0078	7.8	7.0	Very Fine Silt	
Analyzed by Pipette or Hydrometer	0.0039	3.9	8.0		U
	0.0020	2.0	9.0		D
	0.00098	0.98	10.0	Clay (Note: Some use 2μ (or 9ϕ) as the clay boundary.)	
	0.00049	0.49	11.0		
	0.00024	0.24	12.0		
	0.00012	0.12	13.0		
	0.00006	0.06	14.0		

LEA

Table 2
Modified Burmister System Descriptors

Fractions		Proportion Descriptors		
(+)	Major Fraction	Quantity	Descriptor	Abbreviation
(-)	Minor Fraction	35% - 50%	and	a
e.g., a medium to coarse SAND which is predominantly medium grained would be written as: m(+) - c SAND		20% - 35%	some	s
		10% - 20%	little	l
		1% - 10%	trace	t
		Modifiers: (+) Upper ⅓ of the range (-) Lower ⅓ of the range		

Table 3
Plasticity of Sediment Samples

Material	Symbol	Feel	Ease of Rolling Thread	Minimum Thread Diameter	Plasticity Index	Plasticity
Clayey SILT	CyM	Rough	Difficult	1/4"	1 to 5	Slight (Sl)
SILT & CLAY	M & C	Rough	Less Difficult	1/8"	5 to 10	Low (L)
CLAY & SILT	C & M	Smooth, dull	Readily	1/16"	10 to 20	Medium (M)
Silty CLAY	MyC	"Shiny"	Easy	1/32"	20 to 40	High (H)
CLAY	C	Waxy, very shiny	Easy	1/64"	40 +	Very High (VH)

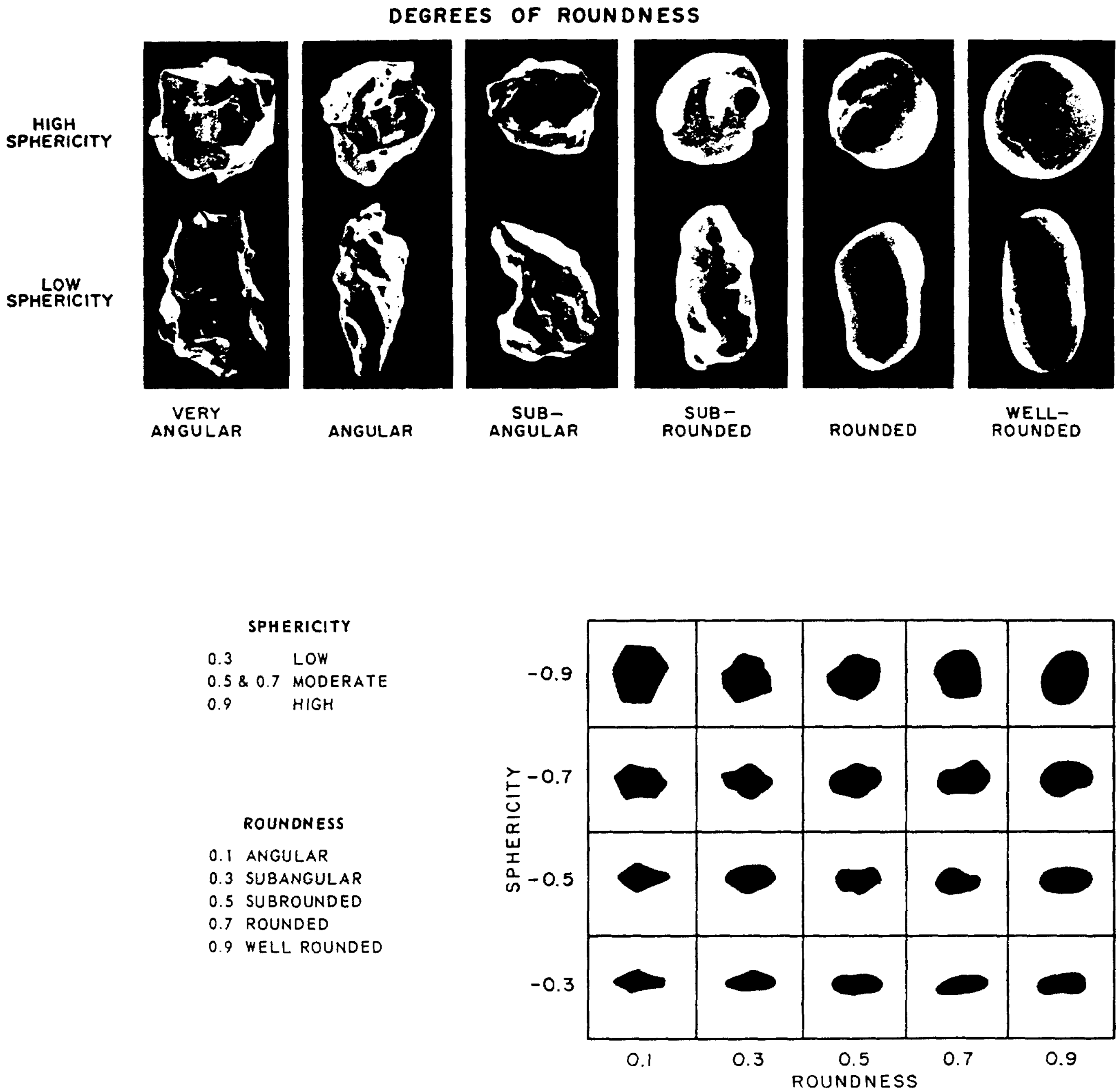
Table 4
Density and Cohesiveness of Sediment Samples

Density of Cohesionless Soils		Consistency of Cohesive Soils	
Blow Counts	**Relative Density**	**Blow Counts**	**Consistency**
0 to 4	Very Loose	0 to 2	Very Soft
5 to 9	Loose	2 to 4	Soft
10 to 29	Medium Dense	4 to 8	Medium
30 to 49	Dense	8 to 15	Stiff
50 to 79	Very Dense	15 to 30	Very Stiff
80 or more	Extremely Dense	30 or more	Hard

Table 5
Description of Sediment Properties

Sediment Parameter	Properties
Color	The color of the sample should be described for the wet sediments. If possible the color should be referenced to a standard color chart such as a Munsell® Color Chart.
Primary Grain Size	Primary grain size refers to the size of the predominant sedimentary size class within the material (as judged visually). The grain size divisions should conform to the standard Wentworth Scale divisions, as shown in Table 1.
Secondary Grain Size(s)	Secondary grain size(s) refer to material which, as a grain-size group, comprises less than the majority of the sediment. Aside from stating the size classification, the relative percentage of the material must be stated. The grain size divisions should conform to the standard Wentworth Scale divisions as shown in Table 1. To describe the approximate percentage of the secondary grain size(s) present, qualifiers shown in Table 2 should be used.
Moisture Content	The moisture content of the sample should be described as **dry**, **slightly moist**, **moist**, or **wet**. Gradation from one state to another should be recorded as, for example, **moist to wet**, or **moist → wet**.
Sorting	The relative degree of sorting of the sediment should be indicated as **poor**, **moderate**, **good**, or **very good**. The degree of sorting is a function of the number of grain size classes present in the sample; the greater the number of classes present the poorer the sorting. In addition, for samples composed only of sand, the relative degree of sorting is a function of the number of sand-size subclasses present.
Sphericity	Sphericity is a measure of how well the individual grains, on average, approximate a sphere. The average sphericity of the sand and larger size fractions should be described as **low**, **moderate** or **high**. A chart illustrating various degrees of sphericity is presented in Figure 1.
Angularity	Angularity, or roundness, refers to the sharpness of the edges and corners of a grain (or the majority of the grains). Five degrees of angularity are shown in Figure 1: **Angular** (sharp edges and corners, little evidence of wear); **Subangular** (edges and corners rounded, faces untouched by wear); **Subrounded** (edges and corners rounded to smooth curves, original faces show some areas of wear); **Rounded** (edges and corners rounded to broad curves, original faces worn away); and, **Well Rounded** (no original edges, faces, or curves, no flat surfaces remain on grains).
Sedimentary Structures	Sedimentary structures are such things as varved layers, distinct bedding, or stratification.
Density -or- Cohesiveness	The density of cohesion of a sample (for the purposes of this application) refer to the sample's resistance to penetration by a sampling device. Density is used in reference to sediments primarily silt-size and coarser while cohesiveness is used in reference to primarily clay-sized sediments. Density or cohesiveness can be assessed from the number of blows from "standard" split-spoon sampling (i.e., 140# hammer, 30" fall, 2" X 2" (O.D., 1 3/8" I.D.)) split-spoon samplers according to the scale in Table 3.

FIGURE 1



DEGREES OF ROUNDNESS
HIGH SPHERICITY
LOW SPHERICITY
VERY ANGULAR
ANGULAR
SUB-ANGULAR
SUB-ROUNDED
ROUNDED
WELL-ROUNDED
SPHERICITY
0.3 LOW
0.5 & 0.7 MODERATE
0.9 HIGH
ROUNDNESS
0.1 ANGULAR
0.3 SUBANGULAR
0.5 SUBROUNDED
0.7 ROUNDED
0.9 WELL ROUNDED
SPHERICITY
-0.9
-0.7
-0.5
-0.3
0.1
0.3
0.5
0.7
0.9
ROUNDNESS

Standard Operating Procedure
for
Performing Slug/Bail Tests

SOP ID: 10021
Date Initiated: 11/21/96

Approved By: ________________________ 11/21/96
Name 1 **Date**

Gail S. Batchelder 11/21/96
Name 2 **Date**

LEA

Standard Operating Procedure
for
Performing Slug/Bail Tests

SOP ID: 10021
Date Initiated: 11/21/96

Approved By:________________________________ __________
Name 1 **Date**

________________________________ __________
Name 2 **Date**

LOUREIRO ENGINEERING ASSOCIATES

Standard Operating Procedure for

Performing Slug/Bail Tests

1.0 Statement of Purpose

This standard operating procedure (SOP) is designed to describe the methodology and procedures used to conduct rising or falling head tests (more commonly known as slug/bail tests) in groundwater monitoring wells. The methods are generally applicable to monitoring wells completed in confined or unconfined aquifers, and differences in procedure for different types of aquifers are noted. The procedures identified in this SOP are specifically for the field activities associated with performing the slug test.

A slug/bail test (hereinafter referred to simply as "slug test") is a simple method for determining local hydraulic properties of an aquifer by measuring the response of the water level in a well (or Piezometer) to the rapid injection or withdrawal of a known volume of water or some solid material (such as a Teflon® slug) which changes the water level in the well. This method is particularly suitable for measuring the properties of relatively low-permeability materials, where the rate of change of the water level will be relatively slow.

Also included with this SOP are general guidelines for the analysis of the data. Because the interpretation of data collected from any type of aquifer analysis is complex, subject to limitations and assumptions in the model(s), and reflective of subtleties in geologic and hydrogeologic conditions, the interpretation of any aquifer analysis data should only be performed by persons familiar with the analytical methods and their limitations and the local hydrogeologic conditions.

2.0 Equipment and Decontamination

2.1 Equipment Supplied by LEA

- Slug, typically a stainless steel or Teflon® bailer, solid Teflon® slug or another type of cleanable or disposable object capable of displacing a suitable volume of water in the monitoring well.
- Disposable cord
- Electronic sounding device
- Data logger and pressure transducer
- Field forms
- Stop watch or watch with second hand or display

- Indelible marker
- Alconox®, or other non-phosphate laboratory-grade detergent
- Three 5-gallon buckets
- Decontamination brushes
- Distilled, de-ionized water
- Decontamination fluids (as specified for site-specific conditions).
- 100-foot measuring tape
- Personal protective equipment as specified in the Site-Specific Health and Safety Plan for site operations and for equipment decontamination.
- Trash bags
- Polyethylene sheeting (5-mil thickness)
- Aluminum foil
- Flashlight
- Spare batteries
- Field book
- Clipboard
- Well wrench(es)
- Keys for well lock(s)
- Laptop computer (if available)

2.2 Equipment and Procedure Selection

In choosing equipment and procedures for slug test, the following general guidelines should be considered:

- The largest slug volume consistent with the analytical method and well construction limitations should be used. The larger the slug volume, the larger the displacement of the water table within the monitoring well and the more accurate the analysis of the data. However, the larger the slug, the more difficult it is to withdraw the slug "instantaneously", since the slug's length must necessarily increase (for a given diameter) to increase the volume; moreover, the larger the slug, the heavier it will be and the more physically difficult it will be to lift out of the water.

  In addition, the diameter of the slug should be chosen so that it will not interfere with the transducer cable in the well. The drawdown data will be invalidated if the transducer cable is moved during the test.

- The rating of the pressure transducer should exceed the placement depth, but should not typically be any greater than necessary.

- If possible, a data logger should be chosen that is capable of collecting data at logarithmic or pseudo-logarithmic time intervals.

- In unconfined aquifers, a slug injection test should not be performed if the monitoring well is screened across the water table because the wetting front created by water flow outward through the unsaturated zone cannot be accounted for analytically.

2.3 Equipment Decontamination

All materials and equipment which enter a monitoring well must be clean and free of any potential contaminants. In general, the choice of decontamination procedures should be based upon a knowledge of the site-specific contaminants and outlined in the site-specific work plan.

For sites at which the contaminants are unknown, but contamination is suspected, the decontamination procedures outlined below should be followed.

2.3.1 Prior to commencing any field activities, the following solutions should be prepared and placed into 500 ml-laboratory squirt bottles: methanol in water (less than 10% solution); 10% nitric acid in water; 100% n-hexane; distilled, de-ionized water.

2.3.2 In the field, prepare approximately 2.5 gallons of a solution of Alconox® (or other suitable non-phosphate laboratory grade detergent) in tap water in a 5-gallon bucket.

2.3.3 Prepare a piece of 5-mil polyethylene sheeting to underlie the decontamination area. The sheeting should be of sufficient size to contain any accidental discharge of decontamination solutions.

2.3.4 The order for decontaminating equipment is as follows:
1) Detergent scrub
2) DI water rinse
3) Hexane rinse
4) DI water rinse
5) 10% nitric acid rinse
6) DI water rinse
7) Methanol rinse (<10% solution)
8) Air dry

2.3.5 Materials such as the cord should not be decontaminated and should just be disposed of after each test.

2.3.6 Wrap each piece of decontaminated equipment in aluminum foil to maintain cleanliness.

2.3.7 At the end of the project day, dispose of all spent decontamination fluids and materials such as the polyethylene sheeting and personal protective equipment in accordance with all applicable municipal, state, and federal regulations.

3.0 Slug-testing Procedures

Prior to designing any slug test, the hydrogeologic conditions in the aquifer and the specifics of well construction should be reviewed by a hydrogeologist or engineer familiar with the various methodologies and qualified to make decisions regarding the performance and interpretation of various types of aquifer tests.

Slug tests may be performed using either manual measurements or automated data collection systems (pressure transducer and data logger). The following procedures describe both methods. Wherever possible, automated equipment is preferred because it allows more rapid and consistent data collection. If manual data collection methods are used, two people should be present so that one can make the measurements and the other can record the data.

3.1 Preliminary Data Collection

Prior to commencing the slug or bail test, the following data should be recorded on the appropriate field form:

1) Date and Time;
2) Name or initials of the field personnel conducting test;
3) Monitoring well identifier (as marked on the well, if the well is marked);
4) Depth to water;
5) Depth to the bottom of the well;
6) Volume of the slug;
7) Screened interval of the monitoring well;
8) Equipment being used to measure water level in the well;
9) Size and construction of filter pack and seals (if known);
10) Diameter of the monitoring well casing;
11) Diameter of the monitoring well screen;
12) Other pertinent information, as required.

A copy of the field form used for the performance of slug tests is attached to this SOP.

3.2 Equipment Set-up

Prior to commencing the slug test, all equipment should be checked to determine if it is in good working order and that it has been properly decontaminated.

3.2.1 Open the monitoring well following the procedures outlined in LEA's *Standard Operating Procedure for Liquid Sample Collection and Field Analysis* (SOP #10004), and measure the depth to water to the nearest 0.01 feet.

3.2.2 If a pressure transducer and data logger are being used, the transducer should be carefully placed into the well at a depth determined to be below the lowest level the water table will reach during the rising-head slug test (or below the lowest point the slug will reach if a falling-head slug test is being conducted). The transducer should be carefully fixed into position so that it will not move during the slug test. Record the depth at which the pressure transducer's measuring point is placed.

3.2.3 If a rising-head slug test is being conducted, the slug should carefully be inserted into the well until it is just below the water table. The water level in the monitoring well should then be allowed to return to within 0.01 feet of its pre-disturbance level.

3.2.4 If a data logger is being used, the data logger should be programmed as necessary. The user should refer to the data logger's manual for the necessary instructions. The data logger should, if possible, be programmed to record data on a logarithmic or pseudo-logarithmic time scale. If this is not possible, the data logger should be programmed to collect data at a rate adequate to collect sufficient early-time data. This rate will necessarily vary between different data loggers, and the user's manual should be consulted.

3.3 Conducting the Slug-Test

Once the water level in the monitoring well has returned to its pre-disturbance (static) level, the slug-test may be performed.

3.3.1 If a rising-head slug test is being conducted, remove the bailer or slug rapidly from the monitoring well and simultaneously begin recording data (water levels and time) whether or not a data logger is being used. If using a data logger, the data logger should be started simultaneously with removal of the slug from the water.

If manual water-level measurements are being made, the data should be collected as rapidly as possible, especially in the early portion of the test. If possible, two operators should be available so that one can make the water-level measurements and the other can record the data on the field forms.

A practical schedule for manually collecting water-level measurements is as follows:

Elapsed Time (minutes)	Frequency of Measurements
0 - 1	Every 10 seconds
1 - 3	Every 20 seconds
3 - 6	Every 30 seconds
6 - 10	Every 60 seconds
10 - 20	Every 2 minutes
20 - 60	Every 5 minutes
60 - 120	Every 10 minutes
120 - 180	Every 20 minutes

Collection of water-level measurements should be continued until the water level is within 0.01 feet of the static (pre-disturbance) level.

3.3.2 If a falling-head slug test is being conducted, rapidly insert the slug below the water level in the monitoring well and simultaneously begin recording data. The slug should be inserted sufficiently far below the water table that it will not interfere with subsequent data collection. However, in no event should the slug be moved once it has been placed into the well because this will affect water-level measurements and invalidate the test.

Data for a falling-head slug test should be recorded in exactly the same manner as for a rising-head slug test.

3.3.3 All data should be recorded on the appropriate field forms in indelible marker in accordance with LEA's *Standard Operating Procedure for Quality Assurance/Quality Control Measures for Field Activities* (SOP #10005).

3.4 Equipment Removal

3.4.1 Upon completion of the slug test, remove all equipment and materials from the well and secure the well (replace cap, cover, and lock).

3.4.2 Decontaminate all equipment that has come in contact with groundwater as described in Section 2.3. Dispose of all expendable materials in a manner consistent with all applicable municipal, state, and federal regulations.

4.0 Data Processing Guidelines

As soon as practicable after the completion of the test, all data loggers should be returned to the office and the data from the test downloaded to a computer. The data files should be stored on disk(s) and also printed as soon as possible. Copies of these printouts should be attached to the field plots and records for that well for permanent storage.

If possible, the data may be downloaded in the field and graphed to check the integrity of the data. The user's manual for the data logger should be consulted for the appropriate downloading procedures. Data downloaded from a data logger should be compared to the manually collected water-level data to ensure the integrity of the measurements.

5.0 Data Analysis

Data collected during the slug test will be analyzed in accordance with published methodologies that are appropriate for the type of aquifer (confined or unconfined) and specifics of well construction. Acceptable methodologies for unconfined or confined aquifers include Hvorslev (1957) and Bouwer and Rice (1976). For a confined aquifer, the methodology developed by Cooper, Bredehoeft, and Papadapulos (1967) may also be used. Analysis of the data should be performed by a hydrogeologist or engineer familiar with the various methodologies and qualified to evaluate the results of slug tests and tests to determine aquifer characteristics in general.

SLUG TEST
DATA RECORD

Project Name:	Project Location:	Monitoring Well:
Project No:	Volume of Slug:	
Field Personnel:	Saturated Aquifer Thickness:	☐ Estimated ☐ Known
Company Performing Test:	Measurement Method:	
Static Water Level:	Reference Point:	
Elevation of Reference Point:	Radius of Filter Pack or Open Borehole:	☐ Estimated ☐ Known
Radius of Casing:	Length of Screen or Open Borehole:	
☐ Injection Test ☐ Bail Test	Type of Slug:	

Date	Clock Time	Water Level Measurements	Correction or Conversion	Notes

SLUG TEST
DATA RECORD

Page ____ of ____

Project Name:	Project Location:	Monitoring Well:

Date	Clock Time	Water Level Measurements	Correction or Conversion	Notes

Data Logger
Field Record

Page ___ of ___

Monitoring Well: ____________
DataLogger Channel In-Use: ____________
Pumping Well ID: ____________
Distance from Pumping Well: ____________
Tranducer Rating or Range: ____________
Tranducer Serial No: ____________
Extension Cable in Use? ☐ Yes ☐ No
Extension Cable Length: ____________
Extension Cable Serial No: ____________
Data Logger Serial No: ____________
Depth of Transducer Placement: ____________
Time Trandsucer Initially Placed: ____________

Monitoring Well: ____________
DataLogger Channel In-Use: ____________
Pumping Well ID: ____________
Distance from Pumping Well: ____________
Tranducer Rating or Range: ____________
Tranducer Serial No: ____________
Extension Cable in Use? ☐ Yes ☐ No
Extension Cable Length: ____________
Extension Cable Serial No: ____________
Data Logger Serial No: ____________
Depth of Transducer Placement: ____________
Time Trandsucer Initially Placed: ____________

Monitoring Well: ____________
DataLogger Channel In-Use: ____________
Pumping Well ID: ____________
Distance from Pumping Well: ____________
Tranducer Rating or Range: ____________
Tranducer Serial No: ____________
Extension Cable in Use? ☐ Yes ☐ No
Extension Cable Length: ____________
Extension Cable Serial No: ____________
Data Logger Serial No: ____________
th of Transducer Placement: ____________
.me Trandsucer Initially Placed: ____________

Monitoring Well: ____________
DataLogger Channel In-Use: ____________
Pumping Well ID: ____________
Distance from Pumping Well: ____________
Tranducer Rating or Range: ____________
Tranducer Serial No: ____________
Extension Cable in Use? ☐ Yes ☐ No
Extension Cable Length: ____________
Extension Cable Serial No: ____________
Data Logger Serial No: ____________
Depth of Transducer Placement: ____________
Time Trandsucer Initially Placed: ____________

Monitoring Well: ____________
DataLogger Channel In-Use: ____________
Pumping Well ID: ____________
Distance from Pumping Well: ____________
Tranducer Rating or Range: ____________
Tranducer Serial No: ____________
Extension Cable in Use? ☐ Yes ☐ No
Extension Cable Length: ____________
Extension Cable Serial No: ____________
Data Logger Serial No: ____________
Depth of Transducer Placement: ____________
Time Trandsucer Initially Placed: ____________

Monitoring Well: ____________
DataLogger Channel In-Use: ____________
Pumping Well ID: ____________
Distance from Pumping Well: ____________
Tranducer Rating or Range: ____________
Tranducer Serial No: ____________
Extension Cable in Use? ☐ Yes ☐ No
Extension Cable Length: ____________
Extension Cable Serial No: ____________
Data Logger Serial No: ____________
Depth of Transducer Placement: ____________
Time Trandsucer Initially Placed: ____________

Monitoring Well: ____________
DataLogger Channel In-Use: ____________
Pumping Well ID: ____________
Distance from Pumping Well: ____________
Tranducer Rating or Range: ____________
Tranducer Serial No: ____________
Extension Cable in Use? ☐ Yes ☐ No
Extension Cable Length: ____________
Extension Cable Serial No: ____________
'a Logger Serial No: ____________
.pth of Transducer Placement: ____________
Time Trandsucer Initially Placed: ____________

Monitoring Well: ____________
DataLogger Channel In-Use: ____________
Pumping Well ID: ____________
Distance from Pumping Well: ____________
Tranducer Rating or Range: ____________
Tranducer Serial No: ____________
Extension Cable in Use? ☐ Yes ☐ No
Extension Cable Length: ____________
Extension Cable Serial No: ____________
Data Logger Serial No: ____________
Depth of Transducer Placement: ____________
Time Trandsucer Initially Placed: ____________

Standard Operating Procedure
for
Conducting Step-Drawdown Pumping Tests

SOP ID: 10022
Date Initiated: 11/21/96

Approved By: ______________________ 11/21/96
Name 1 **Date**

Gail L Batchelder 11/21/96
Name 2 **Date**

LEA

LOUREIRO ENGINEERING ASSOCIATES

**Standard Operating Procedure
for
Conducting Step-drawdown Pumping Tests**

1.0 Statement of Purpose

A step-drawdown test is a pumping test conducted on a single well which consists of pumping the well at a series of increasingly higher discharge rates. The test should consist of pumping at a minimum of three discharge rates. The pumping intervals must be of sufficient length that drawdown in the well stabilizes during each step, except possibly the last one.

Step-drawdown tests are typically used to assess the performance of a production well, especially prior to conducting a major pumping test on the well. Drawdown in a pumped well is a combination of the aquifer losses and well losses and a step-drawdown test is used to evaluate these losses.

This standard operating procedure (SOP) is designed to describe the methodologies and procedures used to conduct step-drawdown pumping tests. This SOP does not address the issues of well construction and installation, actual design of the test itself, or data analysis. It provides procedures only for the actual field procedures involved in conducting a step-drawdown pumping test.

Design of the test itself (which includes selecting or designing the pumping well and observation wells and choosing the appropriate discharge rates and pumping times for each step) and analysis of the data must be performed by a hydrogeologist or engineer familiar with the various methodologies for performing aquifer tests and hydrogeologic conditions in the aquifer. This individual should be qualified to evaluate the data and make decisions regarding the performance and interpretation of various types of aquifer tests.

2.0 Equipment and Decontamination

2.1 Equipment Supplied by LEA

- Pump
- Power source for the pump (e.g., electrical generator, diesel direct-drive, direct power from the mains, etc.)
- Fuel for the power source, or sufficient electrical cords
- Electronic sounding device(s), at least one per person for all gaugers, and possibly a spare

- Discharge monitoring devices (e.g., orifice weir and manometer, calibrated receptacle and timer, electronic flowmeter, etc.)
- Discharge hose, the length, diameter, and type must be chosen based upon the discharge rate chosen for the test, the discharge monitoring device(s), and any contaminants present in the discharge water
- Tubing for stilling well, if practical. The tubing should be of sufficient diameter to accept the measuring device, but small enough to be installed in the well without interfering with the pump
- Data logger and pressure transducer
- Barometer or barometric pressure transducer
- Rain gauge
- Stream and/or tide gauges
- Field forms
- Stop watch or watch with second hand or display
- Indelible marker
- Alconox®, or other non-phosphate laboratory grade detergent
- Three 5-gallon buckets
- Decontamination brushes
- Distilled, de-ionized water
- Decontamination fluids (< 10% methanol in water, 100% n-hexane, and 10% nitric acid)
- 100-foot measuring tape
- Personal protective equipment as specified in the Site-Specific Health and Safety Plan for site operations and for equipment decontamination
- Trash bags
- Polyethylene sheeting (5-mil thickness)
- Aluminum foil
- Flashlight
- Spare batteries
- Field book
- Clipboard
- Well wrench(es)
- Keys for well lock(s)
- Laptop computer (if available)
- Treatment system for discharged water, as necessary
- Discharge permits, as required

2.2 Equipment Decontamination

All materials and equipment which enter a well must be clean and free of any potential contaminants. In general, the choice of decontamination procedures should be based upon a knowledge of the site-specific contaminants and outlined in the site-specific work plan.

For sites at which the contaminants are unknown, but contamination is suspected, the decontamination procedures outlined below should be followed.

2.2.1 Prior to commencing any field activities, the following solutions should be prepared and placed into 500-ml laboratory squirt bottles: 10% methanol in water; 10% nitric acid in water; 100% n-hexane; distilled, de-ionized water.

2.2.2 In the field, prepare approximately 2.5 gallons of a solution of Alconox® (or other suitable non-phosphate laboratory grade detergent) in tap water in a 5-gallon bucket.

2.2.3 Prepare a piece of 5-mil polyethylene sheeting to underlie the decontamination area. The sheeting should be of sufficient size to contain any accidental discharge of decontamination solutions. The plastic should be bermed to contain spills.

2.2.4 The order for decontaminating equipment is as follows:

1) Detergent scrub
2) DI water rinse
3) Hexane rinse
4) DI water rinse
5) 10% nitric acid rinse
6) DI water rinse
7) Methanol rinse (10% solution)
8) Air dry

2.2.5 Materials such as the cord should not be decontaminated and should just be disposed of after each test.

2.2.6 Wrap each piece of decontaminated equipment in aluminum foil to maintain cleanliness.

2.2.7 At the end of the project day, dispose of all spent decontamination fluids and materials such as the polyethylene sheeting and personal protective equipment in accordance with all applicable municipal, state, and federal regulations.

2.3 Equipment Selection

- A pump should be chosen with due regard for the anticipated discharge rates, the static and pumping depths to water, and the power requirements of the pump. A thorough discussion of the selection of pumps is beyond the scope of this document; however, the pump should generally be capable of supplying at least twice the maximum anticipated discharge. The pump should be equipped with a check valve so that water in the pump and the discharge hose is not drawn back into the well when the pump is shut down. The pump should be chosen so that all of the wetted components are composed of material compatible with the concentration and type of contaminants present in the groundwater.

- A power source for the pump should be chosen to provide reliable power through the anticipated duration of the test. Generators should be capable of supplying at least twice the required load so that they are not operated too close to their maximum potential. A generator should also have sufficient fuel capacity that so that frequent refueling is not necessary. The generator should also be designed so that it can be refueled while running. If power from the mains is to be used, the electrical extension cords should be of the appropriate rating and length. Also if power from the mains is to be used, the adequacy of the connection should be ascertained; the connection should be as close to a direct connection to the mains as possible to avoid unintentional disconnection. Regardless of the type of power source used, it must be provided with fused disconnects and motor starters appropriate to the pump being used; the pump manufacturer's literature should be consulted for the appropriate electrical equipment.

- In choosing between using automated water-level measurements or solely manual measurements, automated water-level measurements are preferable, but manual measurements should nevertheless be made in all wells to confirm the automated measurements and provide security in case the automated data collection system fails. Also, manual measurements are more easily graphed in the field to observe how the test is progressing and when to proceed to the next stage.

  Data loggers should be chosen with regard for their ability to record data on a logarithmic scale and the ease with which they may be "restarted", or switched to a new test to change between pumping and recovery tests. Pressure transducers should be chosen with regard to the pressure range and absolute pressures anticipated and the type and concentration of any contaminants present.

Manual water-level indicators should be chosen so that they are graduated in 0.01 foot (or 0.01 meter) increments and are compatible with the type and concentration of any contaminants present.

- Discharge monitoring devices should be suitable for the planned discharge rates; that is, the discharge monitoring device(s) should be able to measure the discharge rates within the reasonable operating range of the device(s). At least two independent discharge monitoring devices should be available; one device should be "unbreakable", for example, a bucket and stopwatch or an orifice weir and manometer. Commercial flowmeters should be installed and operated in accordance with the manufacturer's recommendations.

3.0 Pumping and Recovery Test Procedures

Because of the methodologies used in the analysis of step-drawdown test data, collection of the early-time data for each step (including the recovery portion of the test) is very important. Although every effort should be made to collect early-time drawdown data as rapidly as possible, it is more important that the data be accurately collected.

3.1 Preliminary Data Collection

Prior to commencing the test, the following data should be recorded on the appropriate field forms, copies of which are attached to this SOP:

1) Date
2) Time
3) Name or initials of the field personnel conducting test
4) Well identifier (as marked on the well, if the well is marked)
5) Depth to water
6) Depth to the bottom of the well
7) Screened interval of the well
9) Equipment being used to measure water level in the well
10) Size and construction of filter pack (if known), and seals (if known)
11) Diameter of the well casing
12) Diameter of the well screen
13) Depth to the bottom of the aquifer
14) Other pertinent information, as required

For areas where pumping tests may be influenced by local streams, rivers, or ponds, or in coastal areas where tidal influences may be a concern, surface water and/or tide gauges should be installed prior to commencing the pumping test.

3.2 Equipment Set-up

Prior to commencing the test, all equipment should be checked to determine if it is in good working order and that it has been properly decontaminated.

3.2.1 Open the pumping well following the procedures outlined in LEA's *Standard Operating Procedure for Liquid Sample Collection & Field Analysis* (SOP # 10004) and measure the depth to water to the nearest 0.01 feet.

3.2.2 All surface water and tide gauges should be gauged when the well is gauged.

3.2.3 The pump should be installed in the pumping well at the maximum practical depth. The installation of the pump, the fittings for the pump, and the power source for the pump should be done in accordance with the respective manufacturers' recommendations. The pump discharge should be connected to whatever groundwater treatment system is required.

3.2.4 A stilling well should be installed in the pumping well. The stilling well should extend approximately 5 feet above or below the intake portion of the pump to help avoid disturbances due to turbulence in the well caused by the pump. The pressure transducer or water-level indicator probe should easily fit down the stilling well so that the tube is not blocked and the water level in the stilling well is free to fluctuate.

3.2.4 If a pressure transducer and data logger are being used, the pressure transducer should be carefully placed into the stilling well at a depth determined to be below the lowest levels the water level will reach during the pumping portion of the test. Record the depth at which the pressure transducer's measuring point is placed. The transducer cable should be secured to a stable object (such as a wooden stake driven into the ground near the well head) in such a manner that no damage will be done to the cable.

3.2.4 If a data logger is being used, the data logger should be programmed as necessary. The user should refer to the data logger's manual for the necessary instructions. The data logger should, if possible, be programmed to record data on a logarithmic or pseudo-logarithmic time scale. If this is not possible, the data logger should be programmed to collect data at a rate adequate to collect sufficient early-time data. This rate will vary among data loggers, and the user's manual should be consulted.

3.3 Conducting the Step-Drawdown Test

3.3.1 If a data logger and pressure transducer are being used, the start of pumping and starting the data logger should be coordinated. This may be done by coordinating two people to start the pump and the data logger simultaneously, or the data logger's internal clock can be set and the pump started at the appropriate time.

Even if a data logger and pressure transducers are to be used to collect the water-level data, backup manual measurements should still be made, if possible, although the frequency of the measurements may be reduced. Care should be taken during the collection of the manual water-level measurements so as not to disturb the pressure transducer. The manual measurements are typically more conducive to plotting in the field (see Section 3.3.4), because they are easier to obtain than downloading the data loggers, especially in the earlier portions of the test, and they still serve adequately to characterize the drawdown in the wells. Manual measurements made in addition to automated data collection may require the installation of an additional stilling well.

If only manual water-level measurements are being made, the data should be collected as rapidly as possible, especially in the early portion of the test. If possible, two operators should be available during the early portion of the test so that one can make the water-level measurements and the other can record the data on the field forms.

A practical schedule for manually collecting water-level measurements for each step (including the recovery phase) is noted below:

Elapsed Time (minutes)	Frequency of Measurements
0 - 2	Every 20 seconds
2 - 5	Every 30 seconds
5 - 10	Every 60 seconds
10 - 30	Every 5 minutes
30 - 60	Every 10 minutes
60 - 120	Every 20 minutes
120 - 360	Every 30 minutes
360 - 720	Every 1 hour
720 - 1440	Every 4 hours
1440 - 4320	Every 8 hours
4320 - 7200	Twice each day
7200 - End	Once each day

3.3.2 During the pumping portions of the test, the discharge rate of the pump should be checked at regular intervals and the flow rate should be recorded in the field record. The flow rate from one measuring device should always be checked against another. A constant discharge rate during each step is very important. Should the discharge rate vary by more than approximately 10% during the course of the test, the drawdown data are suspect and the test should be halted and the water-levels allowed to recover. The water-level recovery data should be collected, however, because recovery data are not sensitive to variations in pumping rate.

3.3.3 If variations in the discharge rate are noted, they should judiciously be corrected, being careful not to overcorrect. The adjustments and the time the adjustments were made should be recorded in the field record. Variations in the discharge rate of up to 5% should not be significant overall, but should be carefully noted in the field record. If it is possible to adjust the discharge rate to correct this variation it may be carefully done, but there is a danger of overcorrecting.

Variations in the discharge rate should be judged on the basis of relative accuracy and precision of the discharge monitoring device and the frequency of measurements. Adjustments to the discharge rate should only be made if the actual cause and magnitude of the variation is clearly understood or if a consistent increasing or decreasing trend is observable. For instance, consistent fluctuations above and below the desired discharge rate as measured by an orifice weir probably should not be corrected, but if the discharge appears to be steadily increasing or decreasing an adjustment should be made.

3.3.4 During the pumping portions of the test, once the time between measurements is sufficiently long, the drawdown data should be plotted in the field on log-log and semi-log graph paper. The plots should be made with time, in minutes, on a logarithmic scale. These plots should be reviewed as the pumping test progresses and should be used to determine whether or not the test is running well and when to proceed to the next discharge rate.

3.3.5 All data should be recorded on the appropriate field forms in indelible marker in accordance with LEA's *Standard Operating Procedure for Quality Assurance/Quality Control Measures for Field Activities* (SOP #10005).

3.3.6 After the test is started, the graphs of water level versus time should be reviewed to decide when to proceed to the next higher pumping level. The initial pumping rate should be less than the anticipated maximum pumping rate (based on whatever information is available; for example, driller's logs, pump test results from local wells, etc.). The discharge rate should be increased to the next step when a minimum of four successive water-level measurements in the pumping well indicate that water levels have begun to stabilize (i.e. successive declines in water level are less than 0.1 foot or a minimum of 20 minutes has elapsed). The decision to proceed to the next pumping stage should be made by an experienced observer on the basis of the drawdown curve as plotted in the field.

3.3.7 The increase in the pumping rate should be made quickly, without allowing the well to return to static conditions and without excessive adjustments to the pumping rate. The increases do not have to be made in uniform steps, and if the actual pumping rate is reasonably close to the desired rate, it is only necessary to know the discharge rate accurately.

3.3.8 After the pumping portion of the test is completed, the recovery portion of the test begins. The recovery test should be conducted in exactly the same manner as for the pumping intervals (save for the operation of the pump).

This applies especially to the frequency of water-level measurements. The recovery test should be conducted until the residual drawdown in the well is approximately zero (the exact value is a function of the actual rate of recovery of the well and should be determined on a case by case basis).

During the recovery phase of the test, the well should not be disturbed, that is, the pump should not be removed, since this would create an instantaneous change in the water level in the well and disturb the water-level measurements. The pump should be equipped with a check valve, therefore the discharge hose and other appurtenances may be disconnected and removed from the site (pending any necessary decontamination).

3.4 Equipment Removal

3.4.1 Upon completion of the pumping and recovery phases of the test, remove all equipment and materials from the well and secure the well (replace caps, covers, and locks). Remove and secure all of the other materials (power sources, water-level indicators, etc.) from the site, decontaminating all equipment as necessary.

3.4.2 Decontaminate all equipment that has come in contact with groundwater as described in Section 2.2. Dispose of all expendable materials, decontamination fluids, and contaminated treatment system materials in a manner consistent with all applicable municipal, state, and federal regulations.

4.0 Data Processing Guidelines

As soon as practicable after the completion of the test, all data loggers should be returned to the office, and the data from the test downloaded to a computer. The data files should be stored on disk(s) and also printed as soon as possible. Copies of these printouts should be attached to the field plots and records for that well for permanent storage.

If possible, the data may be downloaded in the field and graphed to check the integrity of the data. The user's manual for the data logger should be consulted for the appropriate downloading procedures. Data downloaded from a data logger should be compared to the manually collected water-level data to ensure the integrity of the measurements.

5.0 Data Analysis

Data collected during the step-drawdown and recovery tests will be analyzed in accordance with published methodologies that are appropriate for the type of aquifer (confined, unconfined, leaky, etc.) and the specifics of the test itself. Acceptable methodologies are presented in Kruseman and de Ridder (1991) and Driscoll (1986), among others. Analysis of the data should be performed by a hydrogeologist or engineer familiar with the various methodologies for conducting aquifer tests and the hydrogeologic conditions in the aquifer. That individual should be qualified to evaluate the results and make decisions regarding various types of aquifer tests.

PUMPING TEST
DATA RECORD

Project Name:	Project Location:	Monitoring Well:
Project No:	Distance from Pumping Well:	
Field Personnel:	Pumping Well ID:	
Company Performing Test:	Measurement Method:	
Static Water Level:	Reference Point:	
	Elevation of Reference Point:	

Date	Clock Time	Time Since Pumping Started	Time Since Pumping Stopped	Water Level Measure.	Correction or Conversion	Discharge Measure.	Pumping Rate	Notes

PUMPING TEST DATA RECORD

Page ____ of ____

Project Name:	Project Location:	Monitoring Well:

Date	Clock Time	Time Since Pumping Started	Time Since Pumping Stopped	Water Level Measure.	Correction or Conversion	Discharge Measure.	Pumping Rate	Notes

Data Logger Field Record

Page ___ of ___

Monitoring Well: ______ **DataLogger Channel In-Use:** ______ Pumping Well ID: ______ Distance from Pumping Well: ______ Tranducer Rating or Range: ______ Tranducer Serial No: ______ Extension Cable in Use? ☐ Yes ☐ No Extension Cable Length: ______ Extension Cable Serial No: ______ Data Logger Serial No: ______ Depth of Transducer Placement: ______ Time Trandsucer Initially Placed: ______	**Monitoring Well:** ______ **DataLogger Channel In-Use:** ______ Pumping Well ID: ______ Distance from Pumping Well: ______ Tranducer Rating or Range: ______ Tranducer Serial No: ______ Extension Cable in Use? ☐ Yes ☐ No Extension Cable Length: ______ Extension Cable Serial No: ______ Data Logger Serial No: ______ Depth of Transducer Placement: ______ Time Trandsucer Initially Placed: ______
Monitoring Well: ______ **DataLogger Channel In-Use:** ______ Pumping Well ID: ______ Distance from Pumping Well: ______ Tranducer Rating or Range: ______ Tranducer Serial No: ______ Extension Cable in Use? ☐ Yes ☐ No Extension Cable Length: ______ Extension Cable Serial No: ______ Data Logger Serial No: ______ Depth of Transducer Placement: ______ Time Trandsucer Initially Placed: ______	**Monitoring Well:** ______ **DataLogger Channel In-Use:** ______ Pumping Well ID: ______ Distance from Pumping Well: ______ Tranducer Rating or Range: ______ Tranducer Serial No: ______ Extension Cable in Use? ☐ Yes ☐ No Extension Cable Length: ______ Extension Cable Serial No: ______ Data Logger Serial No: ______ Depth of Transducer Placement: ______ Time Trandsucer Initially Placed: ______
Monitoring Well: ______ **DataLogger Channel In-Use:** ______ Pumping Well ID: ______ Distance from Pumping Well: ______ Tranducer Rating or Range: ______ Tranducer Serial No: ______ Extension Cable in Use? ☐ Yes ☐ No Extension Cable Length: ______ Extension Cable Serial No: ______ Data Logger Serial No: ______ Depth of Transducer Placement: ______ Time Trandsucer Initially Placed: ______	**Monitoring Well:** ______ **DataLogger Channel In-Use:** ______ Pumping Well ID: ______ Distance from Pumping Well: ______ Tranducer Rating or Range: ______ Tranducer Serial No: ______ Extension Cable in Use? ☐ Yes ☐ No Extension Cable Length: ______ Extension Cable Serial No: ______ Data Logger Serial No: ______ Depth of Transducer Placement: ______ Time Trandsucer Initially Placed: ______
Monitoring Well: ______ **DataLogger Channel In-Use:** ______ Pumping Well ID: ______ Distance from Pumping Well: ______ Tranducer Rating or Range: ______ Tranducer Serial No: ______ Extension Cable in Use? ☐ Yes ☐ No Extension Cable Length: ______ Extension Cable Serial No: ______ Data Logger Serial No: ______ Depth of Transducer Placement: ______ Time Trandsucer Initially Placed: ______	**Monitoring Well:** ______ **DataLogger Channel In-Use:** ______ Pumping Well ID: ______ Distance from Pumping Well: ______ Tranducer Rating or Range: ______ Tranducer Serial No: ______ Extension Cable in Use? ☐ Yes ☐ No Extension Cable Length: ______ Extension Cable Serial No: ______ Data Logger Serial No: ______ Depth of Transducer Placement: ______ Time Trandsucer Initially Placed: ______

Data Logger Field Record

Page ___ of ___

Monitoring Well: ____
DataLogger Channel In-Use: ____
Pumping Well ID: ____
Distance from Pumping Well: ____
Tranducer Rating or Range: ____
Tranducer Serial No: ____
Extension Cable in Use? ☐ Yes ☐ No
Extension Cable Length: ____
Extension Cable Serial No: ____
Data Logger Serial No: ____
Depth of Transducer Placement: ____
Time Trandsucer Initially Placed: ____

Monitoring Well: ____
DataLogger Channel In-Use: ____
Pumping Well ID: ____
Distance from Pumping Well: ____
Tranducer Rating or Range: ____
Tranducer Serial No: ____
Extension Cable in Use? ☐ Yes ☐ No
Extension Cable Length: ____
Extension Cable Serial No: ____
Data Logger Serial No: ____
Depth of Transducer Placement: ____
Time Trandsucer Initially Placed: ____

Monitoring Well: ____
DataLogger Channel In-Use: ____
Pumping Well ID: ____
Distance from Pumping Well: ____
Tranducer Rating or Range: ____
Tranducer Serial No: ____
Extension Cable in Use? ☐ Yes ☐ No
Extension Cable Length: ____
Extension Cable Serial No: ____
Data Logger Serial No: ____
th of Transducer Placement: ____
ne Trandsucer Initially Placed: ____

Monitoring Well: ____
DataLogger Channel In-Use: ____
Pumping Well ID: ____
Distance from Pumping Well: ____
Tranducer Rating or Range: ____
Tranducer Serial No: ____
Extension Cable in Use? ☐ Yes ☐ No
Extension Cable Length: ____
Extension Cable Serial No: ____
Data Logger Serial No: ____
Depth of Transducer Placement: ____
Time Trandsucer Initially Placed: ____

Monitoring Well: ____
DataLogger Channel In-Use: ____
Pumping Well ID: ____
Distance from Pumping Well: ____
Tranducer Rating or Range: ____
Tranducer Serial No: ____
Extension Cable in Use? ☐ Yes ☐ No
Extension Cable Length: ____
Extension Cable Serial No: ____
Data Logger Serial No: ____
Depth of Transducer Placement: ____
Time Trandsucer Initially Placed: ____

Monitoring Well: ____
DataLogger Channel In-Use: ____
Pumping Well ID: ____
Distance from Pumping Well: ____
Tranducer Rating or Range: ____
Tranducer Serial No: ____
Extension Cable in Use? ☐ Yes ☐ No
Extension Cable Length: ____
Extension Cable Serial No: ____
Data Logger Serial No: ____
Depth of Transducer Placement: ____
Time Trandsucer Initially Placed: ____

Monitoring Well: ____
DataLogger Channel In-Use: ____
Pumping Well ID: ____
Distance from Pumping Well: ____
Tranducer Rating or Range: ____
Tranducer Serial No: ____
Extension Cable in Use? ☐ Yes ☐ No
Extension Cable Length: ____
Extension Cable Serial No: ____
ta Logger Serial No: ____
pth of Transducer Placement: ____
Time Trandsucer Initially Placed: ____

Monitoring Well: ____
DataLogger Channel In-Use: ____
Pumping Well ID: ____
Distance from Pumping Well: ____
Tranducer Rating or Range: ____
Tranducer Serial No: ____
Extension Cable in Use? ☐ Yes ☐ No
Extension Cable Length: ____
Extension Cable Serial No: ____
Data Logger Serial No: ____
Depth of Transducer Placement: ____
Time Trandsucer Initially Placed: ____

Standard Operating Procedure
for
Conducting Constant-Rate Pumping and Recovery Tests

SOP ID: 10023
Date Initiated: 11/21/96

Approved By: ______________________ 11/21/96
Name 1 Date

Gail L. Batchelder 11/21/96
Name 2 Date

LEA

LOUREIRO ENGINEERING ASSOCIATES

Standard Operating Procedure
for
Conducting Constant Rate Pumping and Recovery Tests

1.0 Statement of Purpose

Constant-rate pumping tests are used to measure the response of an aquifer to the stress of pumping water. In a constant-rate pumping test, a well is pumped at a constant discharge rate for an extended period of time (typically more than 24 hours), while measuring the drawdown of the water levels in surrounding monitoring wells. Pumping tests are conducted to provide data to estimate the aquifer's hydraulic properties (e.g., hydraulic conductivity, storativity, etc.), to characterize boundary conditions in the aquifer, or to determine the degree of hydraulic connection between flow systems (e.g., overburden-bedrock connectivity). This standard operating procedure (SOP) is designed to describe the methodologies and procedures used to conduct constant-rate pumping and recovery tests. This SOP does not address the issues of well design or installation, design of the pumping test, or data analysis. It provides procedures only for the actual field activities involved in conducting a pumping and recovery test.

The procedures outlined in this document are general guidelines for conducting pumping tests; however, the operator should always determine whether the pumping test being performed is controlled by local, state or federal regulations (for example, a Level "A" Mapping pump test in the State of Connecticut). Alterations or specific actions may be required to comply with all of the applicable regulations.

This standard operating procedure (SOP) is designed to describe the methodologies and procedures used to conduct step-drawdown pumping tests. This SOP does not address the issues of well construction and installation, actual design of the test itself, or data analysis. It provides procedures only for the actual field procedures involved in conducting a step-drawdown pumping test.

Design of the test itself (which includes selecting or designing the pumping well and observation wells and choosing the appropriate discharge rates and pumping times for each step) and analysis of the data must be performed by a hydrogeologist or engineer familiar with the various methodologies for performing aquifer tests and hydrogeologic conditions in the aquifer. This individual should be qualified to evaluate the data and make decisions regarding the performance and interpretation of various types of aquifer tests.

2.0 Equipment and Decontamination

2.1 Equipment Supplied by LEA

- Pump
- Power source for the pump (e.g., electrical generator, diesel direct-drive, direct power from the mains, etc.)
- Fuel for the power source, or sufficient electrical cords.
- Electronic sounding device(s), at least one per gauging crew plus a spare.
- Discharge monitoring devices (e.g., orifice weir and manometer, calibrated receptacle and timer, electronic flowmeter, etc.).
- Discharge hose. The length, diameter, and type must be chosen based upon the discharge rate chosen for the test and any contaminants present in the discharge water, the discharge location, and the flow metering device(s) to be used.
- Tubing for stilling well, if practical. The tubing should be of sufficient diameter to accept the measuring device, but small enough to fit in the well without interfering with the pump.
- Data logger and pressure transducer(s)
- Barometer or barometric pressure transducer
- Rain gauge
- Stream and/or tide gauges
- Field forms
- Stop watch or watch with second hand or display
- Indelible marker
- Alconox®, or other non-phosphate laboratory grade detergent
- Three 5-gallon buckets
- Decontamination brushes
- Distilled, de-ionized water
- Decontamination fluids (<10% methanol in water, 100% n-hexane, and 10% nitric acid.
- 100-foot measuring tape
- Personal protective equipment as specified in the Site-Specific Health and Safety Plan for site operations and for equipment decontamination.
- Trash bags
- Polyethylene sheeting (5-mil thickness)
- Aluminum foil
- Flashlight
- Spare batteries
- Field book
- Clipboard
- Well wrench(es)

- Keys for well lock(s)
- Laptop computer (if available)
- Treatment system for discharged water, as necessary
- Discharge permits, as required

2.2 Equipment Decontamination

All materials and equipment which enter a monitoring or pumping well must be clean and free of any potential contaminants. In general, the choice of decontamination procedures should be based upon a knowledge of the site-specific contaminants and outlined in the site-specific work plan.

For sites at which the contaminants are unknown, but contamination is suspected, the decontamination procedures outlined below should be followed.

2.2.1 Prior to commencing any field activities, the following solutions should be prepared and placed into 500-ml laboratory squirt bottles: methanol in water (<10% solution); 10% nitric acid in water; 100% n-hexane; distilled, de-ionized water.

2.2.2 In the field, prepare approximately 2.5 gallons of a solution of Alconox® (or other suitable non-phosphate laboratory grade detergent) in tap water in a 5-gallon bucket.

2.2.3 Prepare a piece of 5-mil polyethylene sheeting to underlie the decontamination area. The sheeting should be of sufficient size to contain any accidental discharge of decontamination solutions. The edges of the sheeting should be bermed to contain spills.

2.2.4 The order for decontaminating equipment is as follows:

1) Detergent scrub
2) DI water rinse
3) Hexane rinse
4) DI water rinse
5) 10% nitric acid rinse
6) DI water rinse
7) Methanol rinse (< 10% solution)
8) Air dry

2.2.5 Materials such as the cord should not be decontaminated and should just be disposed of after each test.

2.2.6 Wrap each piece of decontaminated equipment in aluminum foil to maintain cleanliness.

2.2.7 At the end of the project day, dispose of all spent decontamination fluids and materials such as the polyethylene sheeting and personal protective equipment in accordance with all applicable municipal, state, and federal regulations.

2.3 Equipment Selection

- A pump should be chosen with due regard for the anticipated discharge rate, the static and pumping depths to water, and the power requirements of the pump. A thorough discussion of the selection of pumps is beyond the scope of this document; however, the pump should generally be capable of supplying at least twice the anticipated discharge. The pump should be equipped with a check valve so that water in the pump and the discharge hose is not drawn back into the well when the pump is shut down. The pump should be chosen so that all of the wetted components are composed of material compatible with the concentration and type of contaminants present in the groundwater.

- A power source for the pump should be chosen to provide reliable power through the anticipated duration of the test. Generators should be capable of supplying at least twice the required load so that they are not operated too close to their maximum potential. A generator should also have sufficient fuel capacity that so that frequent refueling is not necessary. The generator should also be designed so that it can be refueled while running. If power from the mains is to be used, the electrical extension cords should be of the appropriate rating and length. Also if power from the mains is to be used, the adequacy of the connection should be ascertained; the connection should be as close to a direct connection to the mains as possible to avoid unintentional disconnection. Regardless of the type of power source used, it must be provided with fused disconnects and motor starters appropriate to the pump being used; the pump manufacturer's literature should be consulted for the appropriate electrical equipment.

- In choosing between using automated water-level measurements or solely manual measurements, automated water-level measurements are preferable. However, manual measurements should nevertheless be made in all wells to confirm the automated measurements and provide security in case the automated data collection system fails. Also, manual measurements are more easily graphed in the field to observe how the pumping test is progressing.

  Data loggers should be chosen with regard for their ability to record data on a pseudo-logarithmic time scale and the ease with which they may be "restarted", or switched to a new test to change between pumping and recovery tests. Pressure transducers should be chosen with regard to the pressure range and absolute pressures anticipated and the type and concentration of any contaminants present.

Manual water-level indicators should be chosen so that they are graduated in 0.01 foot (or 0.01 meter) increments and are compatible with the type and concentration of any contaminants present.

- Discharge monitoring devices should be suitable for the planned discharge rate; that is, the discharge monitoring device(s) should be able to measure the discharge within the reasonable operating range of the device(s). At least two independent discharge monitoring devices should be available; one device should be "unbreakable", for example, a bucket and stopwatch or an orifice weir and manometer. Commercial flowmeters should be installed and operated in accordance with the manufacturer's recommendations.

3.0 Pumping and Recovery Test Procedures

In typical situations, the pumping portion of the test is conducted before the recovery test. In the unusual case in which the well under test has been operating for a considerable period of time it may be possible to conduct the recovery portion of the test first. However, it should first be determined whether the effected wells are anticipated to recover sufficiently during the recovery portion of the test.

Because of the methodologies used in the analysis of pumping test data, collection of the early-time data is very important. Although every effort should be made to collect early-time drawdown data as rapidly as possible, it is more important that the data be accurately collected. If only manual water-level data are to be used, it is essential that the measurements be recorded against accurate, synchronized times.

3.1 Preliminary Data Collection

Prior to commencing the pumping test, the following data should be recorded on the appropriate field forms for each monitoring well and for the pumping well:

1) Date
2) Time
3) Name or initials of the field personnel conducting test
4) Well identifier (as marked on the well if the well is marked)
5) Depth to water
6) Depth to the bottom of the well
7) Screened interval of the well
9) Equipment being used to measure water level in the well
10) Size and construction of filter pack (if known), and seals (if known)
11) Diameter of the well casing
12) Diameter of the well screen

13) Distance to the pumping well
14) Other pertinent information, as required

Copies of the field forms are attached to this SOP.

Beginning at least one week prior to the actual start of the pumping test, a round of water-level measurements should be made in all the wells. As many rounds of water-level measurements as possible should be made prior to the start of the test. In addition, a rain gauge should be installed in the area of the pumping well and should be checked regularly if there is the possibility that precipitation occurred.

For areas where pumping tests may be influenced by local streams, rivers, or ponds, or in coastal areas where tidal influences may be a concern, surface water and/or tide gauges should be installed prior to commencing the pumping test. These gauges should be read when the water-level measurements are made.

3.2 Equipment Set-up

Prior to commencing the test, all equipment should be checked to determine if it is in good working order and that it has been properly decontaminated.

3.2.1 Conduct a round of water-level measurements in all monitoring wells and the pumping well to establish static conditions. Open the monitoring well following the procedures outlined in LEA's *Standard Operating Procedure for Liquid Sample Collection & Field Analysis* (SOP # 10004) and measure the depth to water to the nearest 0.01 feet.

3.2.2 All surface water, tide, and rain gauges should be gauged when the monitoring wells are gauged.

3.2.3 If pressure transducers and data loggers are being used, the pressure transducers should be carefully placed into the wells at depths determined to be below the lowest levels the water levels will reach during the pumping portion of the test. Record the depths at which the pressure transducers' measuring points are placed. The transducer cables should be secured to stable objects (such as wooden stakes driven into the ground near the well heads) in such a manner that no damage will be done to the cables.

3.2.4 If a data logger is being used, the data logger should be programmed as necessary. The user should refer to the data logger's manual for the necessary instructions. The data logger should, if possible, be programmed to record data on a logarithmic or pseudo-logarithmic time scale. If this is not possible, the data logger should be programmed to collect data at a rate adequate to collect sufficient early-time data. This rate will vary among data loggers, and the user's manual should be consulted.

3.2.5 The pump should be installed in the pumping well at a depth below the maximum anticipated drawdown expected during the test. The installation of the pump, the fittings for the pump, and the power source for the pump should be done in accordance with the respective manufacturers' recommendations. The pump discharge should be connected to whatever groundwater treatment system is required.

If practicable, a stilling well should be installed in the pumping well. The stilling well should extend approximately 5 feet above or below the intake portion of the pump to help avoid disturbances due to turbulence in the well caused by the pump. The pressure transducer or water level indicator probe should easily fit down the stilling well so that the tube is not blocked and the water level in the stilling well is free to fluctuate.

3.2.6 After the pump is installed in the well and properly connected to the treatment system, the water level in the pumping well should be allowed to return to a static level. After the water level in the well returns to static, the discharge rate from the pump must be set. This is accomplished by starting the pump and adjusting the flow to the desired rate; this should be done as quickly as possible, and once the flow rate has stabilized the pump should be shut off and the water level in the well should be allowed to return to its pre-pumping level. The time of pumping and the estimated volume of water pumped should be recorded in the field notes. If a totalizing flowmeter is being used, the readings (before and after the initial pumping) should also be recorded in the field notes.

3.2.7 All of the wells should be provided with some sort of covering to keep foreign objects from being introduced into the well during the course of the test. If manual measurements are being made, the wells can be capped and covered once the time lag between water-level readings is sufficiently long. If a data logger and pressure transducers are being used, the wells should be covered as well as possible, but in such a manner that the transducer cable will not be damaged.

3.3 Conducting the Pumping Test

Once all of the water-level measurements have been made to determine static water levels, the pumping rate in the well has been established, and water levels have been allowed to return to static conditions, the pumping test may begin.

3.3.1 If a data logger and pressure transducers are being used, the start of pumping and starting the data logger should be coordinated. This may be done by coordinating two people to start the pump and the data logger simultaneously, or the data logger's internal clock can be set and the pump started at the appropriate time.

Even if a data logger and pressure transducers are to be used to collect the water-level data, backup manual measurements should still be made, although the frequency of the measurements may be reduced. Care should be taken during the collection of the manual water-level measurements so as not to disturb the pressure transducer. The manual measurements are typically more conducive to plotting in the field (see Section 3.3.4), because they are easier to obtain than downloading the data loggers, especially in the earlier portions of the test, and they still serve adequately to characterize the drawdown in the wells.

If only manual water-level measurements are being made, the data should be collected as rapidly as possible, especially in the early portion of the test. If possible, two operators should be available during the early portion of the test so that one can make the water-level measurements and the other can record the data on the field forms.

A practical schedule for manually collecting water-level measurements is noted below:

Elapsed Time (minutes)	Frequency of Measurements
0 - 2	Every 20 seconds
2 - 5	Every 30 seconds
5 - 10	Every 60 seconds
10 - 30	Every 5 minutes
30 - 60	Every 10 minutes
60 - 120	Every 20 minutes
120 - 360	Every 30 minutes
360 - 720	Every 1 hour
720 - 1440	Every 4 hours
1440 - 4320	Every 8 hours
4320 - 7200	Twice each day
7200 - End	Once each day

3.3.2 During the pumping portion of the test, the discharge rate of the pump should be checked at regular intervals and the flow rate should be recorded in the field record. The flow rate from one measuring device should always be checked against another. A constant discharge rate is very important. Should the discharge rate vary by more than approximately 10% during the course of the test, the drawdown data are suspect and the test should be halted and the water levels allowed to recover. The water-level recovery data should be collected, however, because recovery data are not sensitive to variations in pumping rate.

3.3.3 If variations in the discharge rate are noted, they should judiciously be corrected, being careful not to overcorrect. The adjustments and the time the adjustments were made should be recorded in the field record.

Variations in the discharge rate of up to 5% should not be significant overall, but should be carefully noted in the field record. If it is possible to adjust the discharge rate to correct this variation it may be carefully done, but there is a danger of overcorrecting. Variations in the discharge rate should be judged on the basis of the discharge monitoring devices' relative accuracy and precision and the frequency of measurements. Adjustments to the discharge rate should only be made if the actual cause and magnitude of the variation is clearly understood or if a consistent increasing or decreasing trend is observable. For instance, consistent fluctuations above and below the desired discharge rate as measured by an orifice weir probably should not be corrected, but if the discharge appears to be steadily increasing or decreasing an adjustment should be made.

3.3.4 During the pumping portion of the test, once the time between measurements is sufficiently long, the drawdown data should be plotted in the field on log-log and semi-log graph paper. The plots should be made with time, in minutes, on a logarithmic scale. These plots should be reviewed as the pumping test progresses and should be used to determine whether or not the test is running well and when to stop pumping

3.3.5 All data should be recorded on the appropriate field forms in indelible marker in accordance with LEA's *Standard Operating Procedure for Quality Assurance/Quality Control Measures for Field Activities* (SOP #10005).

3.3.6 In unconfined aquifers, a pumping test should continue for 72 hours at a minimum; in confined aquifers, a pumping test should be continued for 24 hours at a minimum. These times are meant only as rough guidelines and the actual pumping time for any test must be based upon the local geologic and hydrogeologic environments, anticipated boundary conditions of the aquifer, and inadequacies in the monitoring system (for example, correcting for the effects of partial penetration). The decision to stop a pumping test should ultimately be based upon the behavior of the drawdown curves as plotted in the field by an experienced observer. State or other regulations may require certain pumping periods, and the applicable regulations should be consulted prior to designing a pumping test.

3.3.7 After the pumping portion of the test is completed, the recovery portion of the test begins. The recovery test should be conducted in exactly the same manner as the pumping test (save for the operation of the pump). This applies especially to the frequency of water level measurements. The recovery test should be conducted for at least as long as the original pumping test.

During the recovery test, the pumping well should not be disturbed, that is, the pump should not be removed, since this would create an instantaneous change in water level in the well and also disturb water-level measurements. If the pump is equipped with a check valve, the discharge hose and other appurtenances may be disconnected and removed from the site (pending any necessary decontamination).

3.4 Equipment Removal

3.4.1 Upon completion of the pumping and recovery tests, remove all equipment and materials from the wells and secure the wells (replace caps, covers, and locks). Remove and secure all of the other materials (power sources, water-level indicators, etc.) from the site, decontaminating all equipment as necessary.

3.4.2 Decontaminate all equipment that has come in contact with groundwater as described in Section 2.2. Dispose of all expendable materials, decontamination fluids, and contaminated treatment system materials in a manner consistent with all applicable municipal, state, and federal regulations.

4.0 Data Processing Guidelines

As soon as practicable after the completion of the test, all data loggers should be returned to the office, and the data from the test downloaded to a computer. The data files should be stored on disk(s) and also printed as soon as possible. Copies of these printouts should be attached to the field plots and records for that well for permanent storage.

If possible, the data may be downloaded in the field and graphed to check the integrity of the data. The user's manual for the data logger should be consulted for the appropriate downloading procedures. Data downloaded from a data logger should be compared to the manually collected water-level data to ensure the integrity of the measurements.

5.0 Data Analysis

Design of the test itself (which includes selecting or designing the pumping well and observation wells and choosing the appropriate discharge rates and pumping times for each step) and analysis of the data must be performed by a hydrogeologist or engineer familiar with the various methodologies for performing aquifer tests and hydrogeologic conditions in the aquifer. This individual should be qualified to evaluate the data and make decisions regarding the performance and interpretation of various types of aquifer tests.

PUMPING TEST DATA RECORD

Page ____ of ____

Project Name:	Project Location:	Monitoring Well:
Project No:	Distance from Pumping Well:	
Field Personnel:	Pumping Well ID:	
Company Performing Test:	Measurement Method:	
Static Water Level:	Reference Point:	
	Elevation of Reference Point:	

Date	Clock Time	Time Since Pumping Started	Time Since Pumping Stopped	Water Level Measure.	Correction or Conversion	Discharge Measure.	Pumping Rate	Notes

PUMPING TEST DATA RECORD

Page ___ of ___

Project Name:	Project Location:	Monitoring Well:

Date	Clock Time	Time Since Pumping Started	Time Since Pumping Stopped	Water Level Measure.	Correction or Conversion	Discharge Measure.	Pumping Rate	Notes

Data Logger
Field Record

Page ___ of ___

Monitoring Well: ______________________
DataLogger Channel In-Use: ______________________
Pumping Well ID: ______________________
Distance from Pumping Well: ______________________
Tranducer Rating or Range: ______________________
Tranducer Serial No: ______________________
Extension Cable in Use? ☐ Yes ☐ No
Extension Cable Length: ______________________
Extension Cable Serial No: ______________________
Data Logger Serial No: ______________________
Depth of Transducer Placement: ______________________
Time Trandsucer Initially Placed: ______________________

Monitoring Well: ______________________
DataLogger Channel In-Use: ______________________
Pumping Well ID: ______________________
Distance from Pumping Well: ______________________
Tranducer Rating or Range: ______________________
Tranducer Serial No: ______________________
Extension Cable in Use? ☐ Yes ☐ No
Extension Cable Length: ______________________
Extension Cable Serial No: ______________________
Data Logger Serial No: ______________________
Depth of Transducer Placement: ______________________
Time Trandsucer Initially Placed: ______________________

Monitoring Well: ______________________
DataLogger Channel In-Use: ______________________
Pumping Well ID: ______________________
Distance from Pumping Well: ______________________
Tranducer Rating or Range: ______________________
Tranducer Serial No: ______________________
Extension Cable in Use? ☐ Yes ☐ No
Extension Cable Length: ______________________
Extension Cable Serial No: ______________________
Data Logger Serial No: ______________________
pth of Transducer Placement: ______________________
ıme Trandsucer Initially Placed: ______________________

Monitoring Well: ______________________
DataLogger Channel In-Use: ______________________
Pumping Well ID: ______________________
Distance from Pumping Well: ______________________
Tranducer Rating or Range: ______________________
Tranducer Serial No: ______________________
Extension Cable in Use? ☐ Yes ☐ No
Extension Cable Length: ______________________
Extension Cable Serial No: ______________________
Data Logger Serial No: ______________________
Depth of Transducer Placement: ______________________
Time Trandsucer Initially Placed: ______________________

Monitoring Well: ______________________
DataLogger Channel In-Use: ______________________
Pumping Well ID: ______________________
Distance from Pumping Well: ______________________
Tranducer Rating or Range: ______________________
Tranducer Serial No: ______________________
Extension Cable in Use? ☐ Yes ☐ No
Extension Cable Length: ______________________
Extension Cable Serial No: ______________________
Data Logger Serial No: ______________________
Depth of Transducer Placement: ______________________
Time Trandsucer Initially Placed: ______________________

Monitoring Well: ______________________
DataLogger Channel In-Use: ______________________
Pumping Well ID: ______________________
Distance from Pumping Well: ______________________
Tranducer Rating or Range: ______________________
Tranducer Serial No: ______________________
Extension Cable in Use? ☐ Yes ☐ No
Extension Cable Length: ______________________
Extension Cable Serial No: ______________________
Data Logger Serial No: ______________________
Depth of Transducer Placement: ______________________
Time Trandsucer Initially Placed: ______________________

Monitoring Well: ______________________
DataLogger Channel In-Use: ______________________
Pumping Well ID: ______________________
Distance from Pumping Well: ______________________
Tranducer Rating or Range: ______________________
Tranducer Serial No: ______________________
Extension Cable in Use? ☐ Yes ☐ No
Extension Cable Length: ______________________
Extension Cable Serial No: ______________________
ata Logger Serial No: ______________________
epth of Transducer Placement: ______________________
Time Trandsucer Initially Placed: ______________________

Monitoring Well: ______________________
DataLogger Channel In-Use: ______________________
Pumping Well ID: ______________________
Distance from Pumping Well: ______________________
Tranducer Rating or Range: ______________________
Tranducer Serial No: ______________________
Extension Cable in Use? ☐ Yes ☐ No
Extension Cable Length: ______________________
Extension Cable Serial No: ______________________
Data Logger Serial No: ______________________
Depth of Transducer Placement: ______________________
Time Trandsucer Initially Placed: ______________________

Standard Operating Procedure
for
Geoprobe® Screen Point Groundwater Sampling

SOP ID: 10024
Date Initiated: 11/21/96

Approved By:

Name 1	11/21/96 **Date**
Gail P. Batchelder **Name 2**	11/21/96 **Date**

LOUREIRO ENGINEERING ASSOCIATES

Standard Operating Procedure for Geoprobe® Screen Point Groundwater Sampling

1.0 Statement of Purpose

This standard operating procedure (SOP) has been prepared to describe the methods and procedures to be used to collect groundwater samples using the Geoprobe® Screen Point Groundwater Sampling device.

The techniques and procedures are adapted from the Geoprobe Systems Technical Bulletin 94-440, dated April 1994. Teczhniques and procedures associated with operation of the Geoprobe® and the collection of soil samples using Geoprobe® methodologies are presented in the SOP entitled, *Standard Operating Procedures for Geoprobe® Probing and Sampling.*

2.0 Required Equipment

The following equipment is required to collect samples of groundwater using the Geoprobe® Screen Point Sampling Methodologies.

Screen Point Sampler Parts	Part Number
Groundwater Sampler Drive Head	GW-430B
O-Ring for Groundwater Sampler Drive Head	GW-430R
Screen Point Sampler Sheath	GW-440
Drive Point Seat	GW-440-1
O-Ring for Drive Point Seat	GW-440-1R
Screen Sleeve	GW-441
Screen Connector with PRT-Adapter Threads	GW-443
O-Ring for Screen Connector	GW-443R
Screen Insert and Plug (Assembled Unit)	GW-444
O-Ring for Screen Plug	GW-444R
Expendable Drive Point	GW-445
O-Ring for Drive Point	GW-445R
Screen Connector Pin	GW-446
Screen Connector Pin Punch	GW-447

Geoprobe® Tools	Part Number
Probe Rod (4 Foot)	AT-104B
Probe Rod (3 Foot)	AT-10B
Probe Rod (2 Foot)	AT-105B
Probe Rod (1 Foot)	AT-106B
Drive Cap	AT-11B
Pull Cap	AT-12B
Extension Rod	AT-67
Extension Rod Coupler	AT-68
Extension Rod Handle	AT-69

Optional Equipment	Part Number
Tubing Bottom Check Valve	GW-42
Check Balls for Check Valve	GW-42-1
Polyethylene Tubing, 1/4" ID	TB-251
Probe Rod Pull Plate	AT-122
PRT Fitting	PR-25S or PR-30S

3.0 Procedures and Guidelines

Procedures refered to in this section refer specifically to those Geoprobe® operations associated with the use of the screen point sampler. All other Geoprobe® operations are described in the SOP entitled *Standard Operating Procedures for Geoprobe® Probing and Sampling.*

3.1 Basic Operation

The outer appearance of the Screen Point Groundwater Sampler, once it has been assembled properly, looks just like a normal Geoprobe® 3-foot probe rod. The bottom is fitted with an expendable drive point, while the top of the sampler can be connected to Geoprobe® rods and other accessories. The assembled sampler can be driven either hydraulically by any Geoprobe® Model 5400 machine, manually using drilling machines, or by using cone penetrometers.

At sampling depth the probe rods attached to the sampler are retracted two feet to allow the sampler screen to be pushed out into the formation.

3.2 Assembly

- Push the screen insert and plug (GW-444) equipped with an O-ring (GW-444R) into the screen sleeve (GW-441) which is the end of the screen sleeve with only one drain hole.

- Push the screen connector (GW-443), which is fitted with an O-ring (GW-443R) over the top of the screen sleeve and secure with the connector pin (GW-446). The pin can easily fall out since it is a rather loose fit.

- Insert the screen connector end of the assembled screen halfway into the screen point sampler sheath (GW-440) from either end. Again, the screen connector end is inserted first.

- Slide the drive point seat (O-ring GW-440-1R) over the protruding end of the screen sleeve and screw it tightly into the sampler sheath.

- Push the screen sleeve up into the sampler sheath just far enough to fit the expendable drive point (O-ring GW-445R) into the bottom end of the drive point seat.

- Screw the O-ring end of the water sampler drive head (GW-430B) into the top of the sampler sheath. Make sure all threads are fastened tightly.

3.3 Probing

- Drive the water sampler approximately two feet below the depth level where you want to sample by attaching it to the Geoprobe® rods.

- Never drive the water sampler without the O-ring (GW-445R) attached to the drive point. Failure to use this O-ring may result in flowing soils clogging the screen during driving.

3.4 Screen Deployment

Once the screen point sampler has been driven to the base of the interval desired for sampling, the probe rods are retracted a distance of two feet and the screen is pushed out into the formation. The following procedures should be used:

- Retract the probe rods from the ground a distance of two feet.

- Insert Geoprobe® stainless steel extension rods (AT-67) down the bore of the probe rods. An extension rod coupler (AT-68) must be placed at the bottom end of the lead extension rod in order to protect the threads at the end of this rod. One extension rod will be required for each probe rod in the ground, plus one extension rod for the screen point sampler itself. Place an extension rod handle (AT-69) at the top of the extension rod string.

- When the proper number of extension rods have been coupled together and inserted down the bore of the probe rods, the last extension rod will protrude from the top of the probe rods a distance of approximately 24 inches.

- Pushing down on the extension rods should now push the screen out into the formation. When the screen is completely pushed out, the extension rod handle will come to rest at a final position approximately 3 inches above the top of the probe rods.

- In extreme situations, it may be necessary to tap on the top of the extension rod handle with a hammer in order to force the screen out into the formation.

3.5 General Sampling Considerations

There are two methods for obtaining a sample from the GW-440 series screen point sampler. Groundwater samples can be obtained by bailing or pumping directly from the bore of the probe rods above the screen point. Alternately, a tubing system may be attached directly to the top of the deployed screen and samples pumped to the surface using either a peristaltic pump or other means of vacuum lift.

3.6 Bottom Check Valve Sampling

The most common groundwater sampling method employed is to pump directly form the bore of the probe rods immediately above the screen point using a tubing bottom check valve. This method is often referred to as "sampling from the open rods," and is essentially the same for bottom check valve sampling as it is for bailing. Note that in order for this method to be employed, the piezometric head in the saturated formation must be above the top of the deployed screen point; water from the formation must rise into the probe rods where it can then be pumped to the surface. Sampling is performed as described in the following steps.

- Either 3/8-inch OD Teflon® (TB-30T) or polyethylene (TB-25L) tubing may be used for groundwater sampling. Selection of tubing material should be based on the analytes of interest and the purpose of the groundwater investigation.

- Place a tubing check valve (GW-42) at the bottom end of a roll of tubing. This bottom check valve will fit either of the tubing types listed above.

- Push the tubing, check valve end first, down the bore of the probe rods until it strikes the top of the screen point sampler.

- Lift the tubing approximately 4 inches off the bottom (top of the screen point sampler) and oscillate the tubing up and down in 8-inch to 12-inch strokes. In field practice, the tubing is oscillated up and down by hand at a rate of 60 to 100 strokes per minute. This pumping can yield as much as 500 milliliters of sample per minute.

- Air bubbles appearing in the pumped stream indicate that the pumping action is exceeding recharge from the screen point, allowing air to enter at the check valve end. For most purposes, intermixing of air with the pumped sample is undesirable. The pumping rate should be slowed and balanced with the recharge rate.

- If water cannot be pumped to the surface, sufficient sample may be obtained by using the tubing and check valve as a bailer. Oscillate the tubing to fill it with several feet of sample and then remove the tubing from the rods.

3.7 Sampling Through PRT Tubing

"PRT" (post run tubing) refers to a Geoprobe® proprietary system of tubing and fittings that are used both for vapor and groundwater sampling. This tubing is inserted down the rods after the sampler has already been driven to depth and has been deployed for sampling. The top of the screen point sampler is equipped with a PRT fitting which serves as a receptacle for a corresponding PRT adapter fitted onto the end of the sampling tube.

In practice, the tubing with the PRT adapter at the lower end is inserted down the bore of the probe rods and screwed into the receptacle on the top of the sampler screen. This procedure forms a vacuum-tight sample train from the sampler screen to the ground surface. Sample is normally pumped to the surface using a peristaltic pump or other vacuum source.

The advantage of this method is that the sample is only placed in contact with the stainless steel sampler screen and tubing. The sample is never exposed to a free surface. The disadvantage of this method is that it is limited to maximum groundwater depths of 20 to 28 feet below ground surface.

The following procedures are used to obtain groundwater samples using PRT fittings and tubing.

- Either 3/8-inch OD Teflon® (TB-30T) or polyethylene (TB-25L) tubing may be used for groundwater sampling. Selection of tubing material should be based on the analytes of interest and the purpose of the groundwater investigation. Each of these tubings has a corresponding PRT adapter that is required for this sampling. These adapters are shown in the following table:

Tubing and PRT Adapters

Tubing	Description	PRT Adapter Part Number
TB-30T	3/8-inch Teflon®	PR-30S
TB-25L	3/8-inch Polyethylene	PR-25S

- Place the barbed end of the appropriate adapter into the selected tubing.

- Push the adapter end of the tubing down the bore of the probe rods until it comes into contact with the PRT threads at the top of the screen point sampler.

- Rotate the tubing counter-clockwise at the surface to screw the adapter into the screen point threads. Rotate the tubing several revolutions until the downhole adapter is completely seated and the tubing starts twisting. In this condition, the tubing will rotate backwards (clockwise) when released.

- The tubing can now be attached to a peristaltic pump or vacuum source at the surface.

- After sampling is complete, tubing should be removed by pulling it up at the surface. This will pull the tubing off the barbed end of the tubing adapter and will allow the operator to examine the connection at the top end of the screen point when it is pulled from the ground.

3.8 Sampler Removal and Retrieval

- Remove all sampling tubes from the bore of the probe rods.

- Pull all rods from the ground using the Geoprobe® machine. Care should be taken not to push down on the probe rods during removal.

- Care should be taken to lift the screen point sampler vertically upward at the surface. Pulling the probe rods or sampler from the ground at any direction other than vertical may result in bending of the screen point sampler.

- Dismantle the sampler at the surface and examine it for damage. Decontaminate all parts, replace all O-rings, and re-assemble the sampler for the next sample.

4.0 Sample Handling

All groundwater samples collected by the methods and procedures presented above will be treated exactly as any other groundwater sample. The sample will be handled in general accordance with the procedures and guidelines described in the LEA SOP entitled *Standard Operating Procedure for Liquid Sample Collection and Field Analysis*. However, because of the nature of the screen point sampling method, it is not necessary to attempt to "purge" a screen point sampler or to attempt to stabilize the field parameters prior to collecting the sample.

5.0 Equipment Decontamination

All sampling equipment used to collect groundwater samples must be clean and free of any potential contaminants. In general, the choice of decontamination procedures should be based upon a knowledge of the site-specific contaminants and outlined in the site-specific work plan.

For sites at which the contaminants are unknown, but contamination is suspected, the decontamination procedures outlined below should be followed.

- Prior to commencing any field activities, the following solutions will be prepared and placed into 500-ml laboratory squirt bottles: methanol (<10% solution) in water; 10% nitric acid; 100% n-Hexane; distilled, de-ionized water.

- In the field, prepare approximately 2.5 gallons of a solution of Alconox® (or other suitable non-phosphate laboratory grade detergent) in tap water in a 5-gallon bucket.

- Prepare a piece of 5-mil polyethylene sheeting to underlie the decontamination area. The sheeting should be of sufficient size to contain any accidental discharge of decontamination solutions. The edges of the sheeting should be bermed to contain spills.

- The order for decontaminating equipment is as follows:

    1) Detergent Scrub;
    2) DI Water Rinse;
    3) Hexane Rinse;
    4) DI Water Rinse;
    5) 10% Nitric Acid Rinse;
    6) DI Water Rinse;

7) Methanol (<10% solution) Rinse;
8) Air Dry.

- Wrap each piece of decontaminated equipment in aluminum foil to maintain cleanliness.

- At the end of the project day, all spent decontamination fluids and materials such as the polyethylene sheeting and personal protective equipment will be disposed of in accordance with all applicable municipal, state, and federal regulations.

Standard Operating Procedure
for
Rock Coring and Rock Descriptions

SOP ID: 10025
Date Initiated: 11/21/96

Approved By:

11/21/96
Name 1 **Date**

Gail S. Batchelder 11/21/96
Name 2 **Date**

LOUREIRO ENGINEERING ASSOCIATES

Standard Operating Procedure
for
Rock Coring and Rock Description

1.0 Statement of Purpose

This standard operating procedure (SOP) is designed to describe the methods and procedures to be used to core rock and properly record the observations. The SOP describes the procedures to be followed in collecting and describing rock cores in a uniform and consistent manner. Also included in this SOP are guidelines for completing coring logs and submitting those logs for computer entry.

2.0 Equipment and Equipment Decontamination

2.1 Equipment Supplied by LEA

- Folding rule or scale
- Hand lens
- Color chart
- Sand-size comparator
- Field forms
- Indelible marker(s)
- Stainless-steel spatula(s)
- Alconox®, or other non-phosphate laboratory grade detergent
- Three 5-gallon buckets
- Decontamination brushes
- Distilled, de-ionized water
- Decontamination fluids (10% methanol in water [<10% solution], 100% n-hexane, and 10% nitric acid. The necessary decontamination fluids are site-specific, refer to Equipment Decontamination section for details).
- Small table
- Personal protective equipment as specified in the Site-Specific Health and Safety Plan for site operations and for equipment decontamination
- Trash bags
- Polyethylene sheeting (5-mil thickness)
- Aluminum foil

- Field book
- Clipboard
- Duct tape (to secure core boxes)
- Camera and film

2.2 Equipment Supplied by the Drilling Contractor

- Drilling rig with all tools and appurtenances
- Core barrels
- Core bits
- Bentonite pellets or chips
- Clean filter pack sand (to be mixed with the bentonite for backfilling the core hole)
- Cement-bentonite grout
- Mud-scale to measure densities
- Source of potable water for coring
- Wooden core boxes with spacers and separators
- Steam-cleaning apparatus and supplies
- Suitable containers (e.g., DOT-approved 55-gallon drums with liners) for cuttings, returned coring water, and water generated from steam cleaning
- Tremie pipe (at least sufficient to reach to the maximum anticipated coring depth)
- All necessary permits and licenses

2.3 Equipment Decontamination

All materials and equipment used in the coring operation be clean and free of any potential contaminants. In general, the choice of decontamination procedures should be based upon a knowledge of the site-specific contaminants and outlined in the site-specific work plan.

For sites at which the contaminants are unknown, but contamination is suspected, the decontamination procedures outlined below should be followed.

- Prior to commencing any field activities, the following solutions should be prepared and placed into 500-ml laboratory squirt bottles: methanol in water (<10% solution); 10% nitric acid in water; 100% n-hexane; distilled, de-ionized water.

- In the field, prepare approximately 2.5 gallons of a solution of Alconox® (or other suitable non-phosphate laboratory grade detergent) in tap water in a 5-gallon bucket.

- Prepare a piece of 5-mil polyethylene sheeting to underlie the decontamination area. The sheeting should be of sufficient size to contain any accidental discharge of decontamination solutions. The edges of the sheeting should be bermed to contain spills.

- The order for decontaminating equipment is as follows:

  1) Detergent Scrub
  2) DI Water Rinse
  3) Hexane Rinse
  4) DI Water Rinse
  5) 10% Nitric Acid Rinse
  6) DI Water Rinse
  7) Methanol Rinse (<10% solution)
  8) Air Dry.

- Wrap each piece of decontaminated equipment in aluminum foil to maintain cleanliness.

- At the end of the project day, dispose of all spent decontamination fluids and materials such as the polyethylene sheeting and personal protective equipment in accordance with all applicable municipal, state, and federal regulations.

3.0 Rock Coring Procedures

3.1 Rock Coring Methods

There are various methods available for coring rocks, refer to the site-specific work plan to assure that the method in use is the specified method or an acceptable method. Typical coring methods are described in Table 1. Nominal borehole and rock-core diameters from different core series bits are presented in Table 2.

The choice of coring methods should be based upon the primary objective of the coring program, the type of geologic environment (known or suspected), and the coring equipment available. The coring method or methods to be used during a particular investigation should be specified in the work plan.

3.2 Rock Coring Procedures

During the coring, observe the drilling rig and the coring operation carefully. Note in the field log any unusual conditions or variations from the general norm.

For any coring operation, record the following information in the field log (in addition to the information recorded for any drilling activity):

Core Barrel Type	Record the type and manufacturer of the core barrel used. Record as much information as possible including model numbers and the apparent condition of the barrel.
Core Barrel Size	The size of the core barrel (and core bit) should be recorded using the standard abbreviations presented in Table 2.
Core Bit Type	The type of core bit (e.g., "face-discharge", "tapered-face"), the type of abrasive material, and the manufacturer should be recorded. Also record the initial and final conditions of the bit (e.g., "new", "badly worn", etc.).
Rod Size	The size of the rods used should be noted since this is important in calculating uphole velocities.
Casing Size	If the borehole is cased (permanent or temporary), note the size, type, and construction of the casing along with the depth to which the casing is set. Otherwise, record the nominal borehole diameter and the fact that it is an open borehole.
Drilling Fluid	Record the composition of the drilling fluid and the density if other than potable water is used.

In addition to the above information, note the following items for each core run:

Coring Rate	Record the coring rate based on the measured rate of advance of the core barrel.
Fluid Loss	Record the rate of fluid loss into the borehole and indicate whether it is measured or estimated. If possible, note the time and the depth when the loss begins (or ends).
Circulation Loss	This is complete loss of return of the drilling fluid. Note the time and depth the circulation loss occurs.
Downhole Pressure	Note the downhole pressure the driller is applying. If different pressures are used, record the depths at which the changes occur.
Fluid Circulation Rate	Record at least a qualitative (e.g., "low", "high") estimate of the fluid circulation rate.
Barrel Rotation Rate	Record at least a qualitative (e.g., "slow", "fast") estimate of the barrel rotation rate.

3.3 Core Handling Procedures

Remove the rock core from the core barrel immediately upon recovery and place it in the core box. Use extreme care in removing and placing the core. Place spacer blocks between each core run to separate the core runs; secure the spacer blocks in the core box.

Place all core into the core box from left to right, top to bottom beginning at the upper left corner of the core box (or at the end of the last core run).

Label the core boxes with an indelible marker at each end and on the inside and outside while in the field. The labeling should include the following:

	Inside	Outside
LEA Comm No.	X	X
Project Name	X	
Project Location	X	
Boring No.	X	X
Geologist's Initials	X	
Date	X	X
Depths	X	X

Photograph the core box as soon as possible. The photographs should clearly show the core and the inside labeling of the core box. If necessary, take additional photographs to show specific features of the core. Include a scale (such as a ruler, rock hammer, or other item of known dimensions) in each photograph.

Place only core from one boring in a core box. Do not transfer core samples to new core boxes except unless a problem, such as core box breakage, occurs. If one must transfer core, use extreme care in moving the core and insure that the new core box is labeled correctly.

Secure the lids of the core boxes carefully with tape and handle all boxes so as to minimize disturbing the core.

4.0 Rock Core Descriptions

4.1 Color

The color of the specimen should be recorded using standard color terms and should be judged with the specimen wet. Where possible, the color of the rock specimen should be compared to a standard geologic rock color chart (for example the Munsell® Rock Color Chart). If a color chart is used, the color value, hue and chroma should be recorded, for example, "Reddish brown 5YR 4/4."

4.2 Major Modifiers

Major modifiers are descriptive terms which refer to the rock specimen as a whole. For example, texture, hardness, mineralogy, etc. Record them in the following order.

4.2.1 Texture

Texture refers to physical attributes of the constituent mineral grains such as size, shape, and arrangement. Standard geologic terms should be used for describing the grains, a selection of these terms is presented in Table 3. The textures of sedimentary rocks are typically described on the basis of the degree of rounding of the grains, the degree of sorting of the grains, and the size or sizes of the grains. In igneous and metamorphic rocks, texture refers to degree to which crystal faces are developed, the size of the mineral grains, and the development of systematic orientation of the mineral grains.

4.2.2 Hardness

The hardness of a rock specimen is judged its resistance to scratching by a pocket knife or a geologists pick. Table 4 presents various degrees of hardness and the corresponding descriptors.

4.2.3 Mineralogy

Record the gross mineralogy of the specimen, if the mineral grains are large enough to provide for accurate identification. Standard mineralogic names should be used.

4.2.4 Structures

Any structures visible in the specimen should be described and recorded in the field log. Structures which are visible but not identifiable should be generically described in the field notes along with measurements of their location(s). Structures should include any sedimentary, igneous or metamorphic structures present (for example, cross bedding, pillow structures, or convolute bedding); however, such things as bedding or foliation, faulting, and fractures or joints are described separately.

4.3 Lithology

Whenever possible, the accepted stratigraphic name of the rock should be recorded. If the name is not known, then a generic rock type should be recorded. Any generic rock type descriptions should be as detailed as possible.

4.4 Bedding or Foliation

Visible bedding or foliation should be measured and described. The bedding or foliation may be described qualitatively using the terminology presented in Table 5, or the range of thicknesses may be presented.

4.5 Fractures, Joints, and Faults

Joints are fractures or discontinuities within the rock fabric which represent dislocation of the rock perpendicular to the plane of the fracture without significant movement parallel to the joint. Faults are discontinuities along which there has been significant movement along the plane of the fracture. It is often difficult to distinguish minor faults from simple joints in rock-core size specimens. Evidence of faulting includes the presence of slickensides or fault gouge, or the obvious dislocation of bedding planes, foliations, or geologic structures across the fracture while jointing may be evidenced by the lack of such dislocation. However, the lack of slickensides or fault gouge is not necessarily evidence of the lack of faulting. Descriptive terminology for fractures is presented in Tables 5 and 6.

4.6 Weathering

Weathering of a rock specimen may be evidenced by the degree of fracturing, the hardness of the rock, staining of mineral grains, kaolinization of feldspars, and the overall degree of competency of the rock specimen. Various degrees of weathering are presented in Table 7.

4.7 Secondary Mineralization

Secondary mineralization in fractures should be described as present or not present and, if possible, the mineralogy should be recorded. The description should record the type, thickness, degree of crystallinity, and evidence of staining of the secondary minerals.

4.8 Recovery, Continuity, and Rock-Quality Designation

Recovery is a measure the amount of core retrieved in the core barrel relative to the total length of core run attempted expressed as a percentage. Recovery is affected by many things including the strength of the rock, the amount and type of drilling fluid used, the rate of rotation of the core barrel and the downhole pressure applied during coring.

Continuity is a measure of the degree to which the core is recovered intact. Continuity is dependent on the same things as recovery, but in addition it is also sensitive to the handling of the core barrel during retrieval and removal of the barrel from the borehole. Degrees of continuity are presented in Table 8.

In order to overcome some of the limitations inherent in recovery and continuity determinations, the recovery of the core is also sometimes measured by the rock-quality designation (RQD). The RQD is calculated by:

$$QD = 100 \times \left(\frac{\mathit{Total\ Length\ of\ Core\ Pieces} \geq 4''}{\mathit{Length\ of\ Core\ Run}} \right.$$

Although the RQD is supposed to be an objective measure of rock quality (it has been found that poor rock quality from an engineering perspective is directly related to low RQD values), there are factors which must be considered when calculating and applying RQDs. First, RQD is typically evaluated from cores obtained from NX or larger series, double-tube core barrels. If other types or smaller sizes of core barrels are used, the calculated RQD may be misleading. Second, RQDs are based upon the assumption of 100%, or near 100%, core recoveries. When core recovery is poor (which may happen, for example, due to foreign objects in the borehole, or other outside influences), the RQD also may not be representative of true rock conditions. Third, the effects of fractures developed solely by drilling should not be included in the RQD calculations. Mechanical fractures induced by the coring operation are the result of the stresses created by the drag of the coring bit on the rock and are not indicative of the quality of the rock under other conditions. However, before using pieces smaller than 4" the geologist must be certain that the fractures creating those pieces are really mechanical and not clean, natural fractures.

5.0 Recording Descriptions

5.1 Geologic Coring Logs

Attached to this SOP is a copy of LEA's standard **GEOLOGIC CORING LOG** form. The coring log should be completed for each borehole that is cored. The heading information is self-explanatory. The body of the log contains space for information from each cored interval in the boring as described previously.

Record all observations, both in the field notebook and on the field forms, in indelible ink. Handle all field forms and recorded information in a manner consistent with the requirements of LEA's *Quality Assurance Manual for Sampling and Analysis.*

5.2 Computer Data Entry

After a project is completed, copies of the **GEOLOGIC CORING LOG** forms should be submitted for computer data entry. A completed copy of the **GEOLOGIC BORING LOG/WELL COMPLETION LOG REQUEST FORM** should be attached to the log forms; a copy of the request form is attached to this SOP.

Table 1.
Rock Coring Methods

Method	Description	Notes and Applications
Single-Tube	Consists of a hollow steel tube with a head on one end threaded for drill rod and a connection on the other end for a reaming shell and core bit.	Simplest and most rugged of all coring methods. Useful in homogenous, hard rock formations.
Double-Tube Rigid	Consists of two concentric hollow tubes connected at the head and threaded at the head for drill rod with a connection on the other end for a reaming shell and core bit.	Useful in medium to hard formations when recovery is not a major concern.
Double-Tube Swivel	Consists of two concentric hollow tubes connected at the head with a swivel device and threaded at the head for drill rod with a connection on the other end for a reaming shell and core bit.	Useful in medium to hard formations where recovery is a concern. Good to excellent recovery is possible.
Denison	Consists of two concentric hollow steel tubes. The outer tube rotates and the inner, thin-walled tube is stationary.	Useful only in weak, poorly consolidated formations. Typically used in unconsolidated or very poorly cemented formations.
Wire Line	Consists of a single inner tube fitted at one end for a reaming shell and core bit. The inner tube is retrievable from the outer barrel via the drilling rig's hoists.	Useful in any type of formation. Drilling is rapid with excellent recoveries possible even in weak formations.
Shot-Core	Consists of a hollow steel barrel threaded at one end for drill rod. The abrasive action comes from chilled steel shot added to the borehole during coring.	Unlimited core diameters possible.

Table 2.
Rock Core Series Designations and Dimensions

Core Series	Borehole Diameter[1]		Rock Core Diameter[1]	
	Inches	Millimeters	Inches	Millimeters
AWG,AWM	1.890	48.0	1.185	30.1
AQ, AV	1.890	48.0	1.062	27.0
BWG, BWM	2.359	60.0	1.655	42.0
BQ, BV	2.359	60.0	1.438	36.5
BQ-3	2.359	60.0	1.313	33.5
BX	2.359	60.0	1.432	36.4
EWG, EWM	1.485	37.7	0.845	21.5
HWG	3.907	99.2	3.000	76.2
HWD4	3.672	93.3	2.400	61.0
HQ	3.781	96.0	2.500	63.5
HQ-3	3.781	96.0	2.375	61.1
HXB	3.672	93.3	2.400	61.0
NW (NX)[2]	2.980	75.7	2.115	53.7
NQ, NV	2.984	75.8	1.875	47.6
NQ2	2.980	75.7	1.990	50.5
NQ-3	2.984	75.8	1.750	45.1
NXE	2.980	75.7	1.995	50.7
PQ	4.828	122.6	3.344	85.0
PQ-3	4.828	122.6	3.250	83.0

[1]These are nominal diameters only.
[2]NW is now the preferred designation; however, NX is still widely used.

Table 3.
Rock Texture

Very Coarse Grained	Individual mineral grains are larger than ¼".
Coarse Grained	Individual mineral grains range from approximately ⅛" to ¼".
Medium Grained	Individual mineral grains range from barely visible to the naked eye to approximately ⅛".
Fine Grained	Individual mineral grains are barely discernible to the naked eye.
Amorphous	Individual mineral grains are too small to be discernible to the naked eye.

Table 4.
Rock Hardness

Very Hard	Cannot be scratched with a knife or sharp pick.
Hard	Can be scratched with a knife or pick only with difficulty.
Moderately Hard	Can be scratched with a knife or pick. Gouges or grooves up to 1/4" deep can be excavated with a hard blow of a pick.
Medium Hard	Can be grooved or gouged 1/16" deep by firm pressure on a knife or pick. Can be excavated into chips up to 1" in size by hard blows of a pick.
Soft	Can be gouged or grooved readily with a knife or pick. Can be excavated into pieces several inches in size by moderate pressure on a pick.
Very Soft	Can be carved with a knife and readily excavated with a pick. Pieces up to 1" can be broken off with fingers.

**Table 5.
Fractures, Bedding and Foliation, Spacing and Attitude**

Fractures	Bedding or Foliation	Spacing	Attitude	Angle
Very Close	Very Thin	Less than 2"	Horizontal	0° - 5°
Close	Thin	2" to 1'	Shallow (or Low Angle)	5° - 35°
Moderately Close	Medium	1' to 3'	Moderately Dipping	35° - 55°
Wide	Thick	3' to 10'	Steeply Dipping	55° - 85°
Very Wide	Very Thick	More than 10'	Vertical	85° - 90°

**Table 6.
Rock Discontinuities**

Crack	A partial or incomplete fracture.
Joint	A simple fracture along which no shear displacement has occurred. May occur in joint sets.
Shear	A fracture along which differential movement has occurred parallel to the surface producing striations or polishing. Distinguished from a fault by scale.
Fault	A major discontinuity along which differential movement has occurred producing gouge, slickensides, and possibly severe fracturing in adjacent rock.
Shear or Fault Zone	A band of parallel or sub-parallel closely spaced faults or shears.

Table 7. Rock Weathering	
Fresh	Rock is fresh, minerals are unstained, a few joints may show slight staining.
Very Slight	Rock is generally fresh, joints stained, some joints may show slight clay coatings, broken minerals remain fresh inside.
Slight	Rock generally fresh but joints stained and discoloration may extend into the rock up to 1". Joints may contain clay; some feldspars may be dull and discolored.
Moderate	Significant portions of the rock show discoloration and obvious weathering effects. Most feldspars are dull and discolored and some are clayey.
Moderately Severe	All minerals (except quartz) discolored. All feldspars are dull and discolored and the majority show kaolinization. Rock shows severe loss of strength.
Severe	All minerals (except quartz) discolored. Original rock fabric remains discernible, but majority of rock is saprolitic. All feldspars kaolinized.
Very Severe	All minerals (except quartz) discolored. Original rock fabric remains discernible, but rock is saprolitic. All feldspars kaolinized.
Complete	Rock is reduced to soil and the original rock fabric is indiscernible. Rock is reduced to soil.

Table 8. Continuity of Rock Cores	
Sound	Cores recovered in 8-inch or larger pieces.
Slightly Fractured	Cores recovered in 4- to 8-inch pieces.
Moderately Fractured	Cores recovered in 1- to 4-inch pieces.
Extremely Fractured	Cores recovered in less than 1-inch pieces.

APPENDIX H

Field Performance and Audit Checklists

LEA

FIELD PERFORMANCE AND AUDIT CHECKLIST
for
SOIL BORING AND WELL INSTALLATION

Project: ______________________ **LEA Comm. No.:** __________

Location: ______________________ **Date:** __________

Client: ______________________ **Time:** __________

Field Personnel: ______________________ **Field Auditor:** __________

Yes__ No__ 1) Is there a Work Plan or Standard Operating Procedure (SOP) for soil boring and well installation activities? Comments ______________________

Yes__ No__ 2) Was a briefing held for project participants? Comments ______________________

Yes__ No__ 3) Were additional instructions given to project participants? Comments ______________________

Yes__ No__ 4) Were soil boring and well installation activities being performed in accordance with applicable work plans, SOPs, and/or Work Instructions? Comments ______________________

LEA

Yes__ No__ 5) Are geologic boring and/or rock coring logs being completed properly and as the samples are collected? If applicable, are monitoring well construction diagrams and logs being completed properly and during the course of well installation? Comments ______________________________

____
____
____
____
____

Yes__ No__ 6) Are soil samples generally being collected and handled in accordance with applicable SOPs and Work Instructions (Refer to Field Performance and Audit Checklist for Soil Sample Collection and Analysis for specific items and comments.) Comments ______________________________

____
____
____
____

Yes__ No__ 7) Is the field data record for soil sample collection being used and completed properly? Comments ______________________________

____
____
____
____

Yes__ No__ 8) Was all equipment and instrumentation available, calibrated, and in proper working order? Comments ______________________________

____
____
____
____

Yes__ No__ 9) Were all applicable health and safety procedures being followed? Comments _

____
____
____
____

This page should be used for any additional comments not covered by the previous questions or for the continuation of comments on pages 1 and 2. If comments are continued from the previous page, they should be referenced below by number.

Additional Comments:

LEA

FIELD PERFORMANCE AND AUDIT CHECKLIST
for
SOIL SAMPLE COLLECTION AND HANDLING

Project: ______________________ **LEA Comm. No.:** __________

Location: ______________________ **Date:** __________

Client: ______________________ **Time:** __________

Field Personnel: ______________________ **Field Auditor:** __________

Yes__ No__ 1) Are there quality assurance documents, a Work Plan, and/or Standard Operating Procedures (SOPs) related to soil sample collection activities? Comments ______________________

Yes__ No__ 2) Was a briefing or training session held for project participants? Comments ______________________

Yes__ No__ 3) Were additional instructions regarding sample collection or handling given to project participants? Comments ______________________

Yes__ No__ 4) Are the appropriate field records related to sample collection and handling being used and completed properly? These include: sample labels, chains-of-custody, field sampling records, and geologic boring logs. Comments ______________________

Yes___ No___ 5) Were sample collection and handling activities being performed with applicable quality assurance documents, work plans, SOPs, and/or Work Instructions (including sampling techniques, sampling equipment, container types, and sample preservation)? Comments _______

Yes__ No__ 6) Was all equipment and instrumentation available, calibrated, and in proper working order? Comments ______

Yes__ No__ 7) Were the numbers, frequency, and types of samples collected as specified in the quality assurance documents, work plan, and SOPs? Comments ____

Yes__ No__ 8) Were blank and duplicate samples properly identified? Comments __________

Yes__ No__ 9) Were photographs of the samples taken and documented? Comments ______

Yes__ No__ 10) Were all applicable health and safety procedures being followed? Comments ______

This page should be used for any additional comments not covered by the previous questions or for the continuation of comments on pages 1 and 2. If comments are continued from the previous page, they should be referenced below by number.

Additional Comments:

FIELD PERFORMANCE AND AUDIT CHECKLIST
for
GROUNDWATER SAMPLE COLLECTION AND HANDLING

Project: ______________________ **LEA Comm. No.:** __________

Location: ______________________ **Date:** __________

Client: ______________________ **Time:** __________

Field Personnel: ______________________ **Field Auditor:** __________

Yes__ No__ 1) Are there quality assurance documents, a Work Plan, and/or Standard Operating Procedures (SOPs) related to groundwater sampling activities? Comments ______________________

Yes__ No__ 2) Was a briefing or training session held for project participants? Comments ______________________

Yes__ No__ 3) Were additional instructions regarding sample collection or handling given to project participants? Comments ______________________

Yes__ No__ 4) Are the appropriate field records related to sample collection and handling being used and completed properly? These include: sample labels, chains-of-custody, and field sampling records. Comments ______________________

Yes__ No__ 5) Were sample collection and handling activities being performed in accordance with applicable quality assurance documents, work plans, SOPs, and/or Work

Instructions (including sampling techniques, sampling equipment, container types, and sample preservation)? Comments ______________________

Yes__ No__ 6) Was all equipment and instrumentation available, calibrated, and in proper working order? Comments ______________________

Yes__ No__ 7) Were the numbers, frequency, and types of samples collected as specified in the quality assurance documents, work plan, and SOPs? Comments ________

Yes__ No__ 8) Were blank and duplicate samples properly identified? Comments ________

Yes__ No__ 9) Were all applicable health and safety procedures being followed? Comments _

This page should be used for any additional comments not covered by the previous questions or for the continuation of comments on pages 1 and 2. If comments are continued from the previous page, they should be referenced below by number.

Additional Comments:

LEA

FIELD PERFORMANCE AND AUDIT CHECKLIST
for
WELL DEVELOPMENT

Project: ______________________________ **LEA Comm. No.:** __________

Location: ______________________________ **Date:** __________________

Client: ______________________________ **Time:** __________________

Field Personnel: _________________________ **Field Auditor:** ____________

Yes__ No__ 1) Is there a Work Plan or Standard Operating Procedure (SOP) for well development activities? Comments ______________________

Yes__ No__ 2) Was a briefing held for project participants? Comments ______________

Yes__ No__ 3) Were additional instructions given to project participants? Comments ______________________

Yes__ No__ 4) Is the field data record for well development being used and completed properly? Comments ______________________

Yes__ No__ 5) Were well development activities being performed in accordance with applicable work plans, SOPs, and/or Work Instructions? Comments _____

____
____
____
____

Yes__ No__ 6) Was all equipment and instrumentation available, calibrated, and in proper working order? Comments ______________________

____
____
____
____

Yes__ No__ 7) Were all applicable health and safety procedures being followed? Comments _

____
____
____
____

This page should be used for any additional comments not covered by the previous questions or for the continuation of comments on pages 1 and 2. If comments are continued from the previous page, they should be referenced below by number.

Additional Comments:

FIELD PERFORMANCE AND AUDIT CHECKLIST
for
WASTE MANAGEMENT ACTIVITIES

Project: ______________________________ **LEA Comm. No.:** __________

Location: ______________________________ **Date:** ______________

Client: ______________________________ **Time:** ______________

Field Personnel: ______________________________ **Field Auditor:** __________

Yes__ No__ 1) Is there a Work Plan or Standard Operating Procedure (SOP) for waste management activities? Comments ______________________________

Yes__ No__ 2) Was a briefing held for project participants? Comments ______________________________

Yes__ No__ 3) Were additional instructions given to project participants? Comments ______________________________

Yes__ No__ 4) Are the Waste Management Area Inspection Form and the Waste Management Record being used and completed properly? Comments ____

Yes__ No__ 5) Were waste management activities being performed in accordance with the Waste Management Plan and related work instructions? Comments ______

Yes__ No__ 7) Were all applicable health and safety procedures being followed? Comments _

The following section should be used for any additional comments not covered by the previous questions or for the continuation of comments on pages 1 and 2. If comments are continued from previous items, they should be referenced below by number.

Additional Comments:

APPENDIX I

Field Forms

LOUREIRO ENGINEERING ASSOCIATES, P.C. LEA

DAILY FIELD REPORT

Page ______ of ______

Project: ______ LEA Comm. No: ______ Date: / /

Location: ______

Client: ______ Inspectors: ______ Inspection Time: ______

NON-PRODUCTIVE TIME

Comments

- [ ] Weather ______
- [ ] Equipment Breakdown ______
- [ ] Missing Equipment ______
- [ ] Late ______
- [ ] Other ______

WEATHER

SITE ACTIVITY

- [ ] Sampling Type ______ Number ______ Number of Bottles ______ Method ______
- [ ] Surveying
- [ ] Well Drilling Type ______ Feet ______ Well Installed? Yes No
- [ ] Observation Brief Description ______
- [ ] Construction Supervision Brief Description ______
- [ ] Other Brief Description ______

STATUS OF TOTAL PRODUCTION

Item	Number of Samples			Sample Records		Sampling Days	
	Today	Total to Date	% Complete	Number of Forms	% Complete	To Date	Remaining
Total							

FIELD PERSONNEL:

______

______

______

______

Signature: ______

FE-DFR-1 3/18/94

100 NORTHWEST DRIVE • PLAINVILLE, CT 06062 • (203) 747-6181 • FAX (203) 747-8822

LOUREIRO ENGINEERING ASSOCIATES, P.C.

DAILY FIELD REPORT

Supplemental Sheet

Page ______ of ______

Project: | LEA Comm. No: | Date: / /

Location:

Client: ______ Inspectors: ______ Inspection Time: ______

DESCRIPTION OF SITE ACTIVITIES

Signature: ______

FE-DFR-2 3/18/94

100 NORTHWEST DRIVE • PLAINVILLE, CT 06062 • (203) 747-6181 • FAX (203) 747-8822

LOUREIRO ENGINEERING ASSOCIATES, P.C.

FIELD SAMPLING RECORD

Page ________ of ________

Project: ____________________ LEA Comm No: ____________ Date: /   /

Location: ____________________

Sample ID	Location ID	Time	Sample Type	Depth (ft)	PID Reading	Comments	Dup.

FIELD PERSONNEL: ____________________

____

____

____

Signature: ______________________________

FE-FSR-1 3/21/94

100 NORTHWEST DRIVE • PLAINVILLE, CT 06062 • (203) 747-6181 • FAX (203) 747-8822

LOUREIRO ENGINEERING ASSOCIATES, P.C.

INTERNAL CHAIN OF CUSTODY

COC NO.:

PROJECT NAME: PROJECT LOCATION: LEA COMM. NO.:

SAMPLING EVENT DATE:

PROJECT MANAGER:

SAMPLER:

SAMPLING METHOD:

MATRIX: Soil Vapor Water OTHER:

CONTAINER TYPE:

SAMPLE SOURCE: Monitoring Well Vapor Probe Vapor Extraction Well Soil boring Other

NO.	QTY	SAMPLE NUMBER (Numbers must be assigned by data manager)	SAMPLE LOCATION (Use appropriate location identifiers)	DEPTH (ft)	PID / FID READING (Circle one)	TIME	MASS (g)	SAMPLE CLASS

SIGNATURE	TIME

TRANSFER NUMBER	ITEM NUMBER	TRANSFERS RELINQUISHED BY	ACCEPTED BY:	DATE	TIME

ADDITIONAL COMMENTS

SAMPLE CLASS CODES:

- SB: soil – boring or pit – must include depth from ground or floor surface
- SS: soil – surface – do not include depth
- GW: groundwater – must include depth from reference mark
- SW: surface water
- SL: sludge
- CC: concrete chip
- AS: asphalt
- WP: Wipe
- BKE: equipment blank
- BKT: trip blank
- BKF: field blank
- OT: other – describe in comments

U:\FMCOC\LEA.WPD

LEA MATERIALS LABORATORY

INTERNAL CHAIN OF CUSTODY

COC NO.:

PROJECT NAME:	PROJECT LOCATION:	LEA COMM. NO.: 07MD502

SAMPLING EVENT DATE:

PROJECT MANAGER:	SAMPLING METHOD:
	MATRIX: Soil Vapor Water OTHER:
SAMPLER:	CONTAINER TYPE:
	SAMPLE SOURCE: Monitoring Well Vapor Probe Vapor Extraction Well Soil boring Other

NO.	QTY	SAMPLE NUMBER (Numbers must be assigned by data manager)	SAMPLE LOCATION (Use appropriate location identifiers)	DEPTH (ft)	PID / FID READING (Circle one)	TIME	MASS (g)	SAMPLE CLASS

SIGNATURE	TIME

TRANSFER NUMBER	ITEM NUMBER	TRANSFERS RELINQUISHED BY	ACCEPTED BY:	DATE	TIME

ADDITIONAL COMMENTS

SAMPLE CLASS CODES:

SB: soil– boring or pit – must include depth from ground or floor surface
SS: soil – surface – do not include depth
GW: groundwater – must include depth from reference mark
SW: surface water
SL: sludge
CC: concrete chip
AS: asphalt
WP: Wipe
BKE: equipment blank
BKT: trip blank
BKF: field blank
OT: other – describe in comments

U:\form\farrel\F-MLC-FD.WK3

GEOLOGIC BORING LOG

Project: LEA Comm No: Client: Location:	Start Date End Date	Boring ID

Drilling Contractor:
Drilling Method:
Sampling Method:
Groundwater Observations:
Depth: At: Hours
Depth: At: Hours

Logged By:
Drilling Foreman:
Drill Rig:
Surface Elevation:
Northing:
Easting:

Elevation/ Depth	Sample Information			Sample Description	PID/FID (ppm)
	Sample No.	Recovery (%)	Blows /6"	Color, Prim. Grain Size, Sec. Grain Sizes, Moist, Sort, Spher, Angul, Sed Struct, Density, Cohesive	
0					
4					
8					
12					
16					
20					
24					

Comments:

Boring No:

LOUREIRO ENGINEERING ASSOCIATES, PC
100 Northwest Drive, Plainville, Connecticut, 06062, Phone(203)747-6181 FAX (203)747-8822

GEOLOGIC BORING LOG

Project: LEA Comm No: Client: Location:	Start Date End Date	Boring ID

Elevation/ Depth	Sample Information			Sample Description	PID/FID (ppm)
	Sample No.	Recovery (%)	Blows /6"	Color, Prim. Grain Size, Sec. Grain Sizes, Moist, Sort, Spher, Angul, Sed Struct, Density, Cohesive	
28					
32					
36					
40					
44					
48					
52					
56					

Boring No:

GEOLOGIC BORING LOG

Project: LEA Comm No: Client: Location:	Start Date End Date	Boring ID

Elevation/ Depth	Sample Information			Sample Description	PID/FID (ppm)
	Sample No.	Recovery (%)	Blows /6"	Color, Prim. Grain Size, Sec. Grain Sizes, Moist, Sort, Spher, Angul, Sed Struct, Density, Cohesive	

Boring No:

LOUREIRO ENGINEERING ASSOCIATES, PC
100 Northwest Drive, Plainville, Connecticut, 06062, Phone(203)747-6181 FAX (203)747-8822

ROCK CORING LOG

Project: LEA Comm No: 07MD50 Client: Black & Decker Corporation Location:	Start Date End Date	Boring ID

Drilling Contractor: Drilling Method: Coring Method: Groundwater Observations: Depth: At Hours Depth: At Hours	Logged By: Drilling Foreman: Drill Rig: Surface Elevation: Northing: Easting:

Elev/ Depth	Sample Number	Core Description Color, Major Modifiers, Lithology, Bedding or Foliation, Fractures/Joints and Orientation, Weathering, Hardness, Secondary Mineralization	Recov. (%)	RQD (%) 0 25 50 75 100	Fract. Per Foot	HARDNESS VS S – VH EH	WEATHERING Fr SW MW HW EW

Comments:

Boring No.

Test Pit Log

LOUREIRO ENGINEERING ASSOCIATES, P.C. LEA

PROJECT NAME:_______________ **PROJECT LOCATION:**_______________ **TEST PIT#**_______

Project No:	Contractor:
Test Pit Dimensions: _______ (L) _______ (W) _______ (D)	Equipment Used:
	Inspector:
Groundwater Observations: At _______ ft. After _______ Hours At _______ ft. After _______ Hours	Weather:
	Date:

Depth	Sample Number	Strata Change	Field Mon. Results	Description of Materials

Comments:

An Equal Opportunity Employer

100 NORTHWEST DRIVE • PLAINVILLE, CT 06062 • (203) 747-6181 • FAX (203) 747-8822

LOUREIRO ENGINEERING ASSOCIATES, P.C. LEA

WELL DEVELOPMENT RECORD

Page ______ of ______

Project: ______ LEA Comm. No: ______ Date: / /

Location: ______ Activity Time: Start: ______ End: ______

Client: ______ MONITORING WELL NO: ______

MONITORING WELL DATA

Well Depth ______ ft | Measured / Historical | Top of Well (PVC) / Top of Prot. Casing / ______ | Protective Casing Stick-up (from ground) ______ ft | Protective Casing/Well Diff. ______ ft

Depth To Water ______ ft | Historical Well Depth ______ ft | Well Material: PVC / SS / ______ | Well Dia.: 1.5 inch / 2 inch / 4 inch / ______

Well Integrity: (Yes / No)
- Prot. Casing Secure
- Concrete Collar Intact
- Well Locked
- Other: ______

Height of Water column ______ ft x Well Diameter: 0.09 gal/ft (1.5 in) / 0.16 gal/ft (2 in) / 0.65 gal/ft (4 in) / ___gal/ft (_ in) = Casing ______ gal | Three Well Volumes ______ gal | Total gallons removed from Well ______

Interface Detected: Yes / No. If yes: Lighter / Heavier

Ambient Air VOA ______ ppm
Well Mouth ______ ppm

PURGE DATA

Well Volume Removed	Volume Removed (gallons)	Field Readings: Temperature (C)	pH (su)	Sp. Cond. (umhos/cm)	Turbidity (NTU)	Color
initial	0					

Initial Sample Observations
- Clear ______
- Colored ______
- Cloudy ______
- Turbid ______
- Odor ______
- Sheen ______
- Other (see notes)

COMMENTS: ______

EQUIPMENT DOCUMENTATION

- Centrifugal Pump
- Submersible Pump
- Inertial Pump
- Surge Block
- Peristaltic Pump
- Air Lift Pump

- PVC Bailer
- Stainless Steel Bailer
- Teflon Bailer
- ______
- ______
- ______

Decon Fluids Used
- Liquinox
- Deionized Water
- HNO_3/D.I. Water
- Potable Water
- TSP solution
- Methanol
- ______

Water Level Equip. Used
- Electric Cond. Probe
- Solinst Interface Probe
- ______

FIELD PERSONNEL: ______

Signature: ______

F-FDR-F 7/18/95 Revised: 8/10/95

LOUREIRO ENGINEERING ASSOCIATES, P.C.

WELL DEVELOPMENT SUMMARY RECORD

PROJECT: ______________________________

Location: ______________________________

Sample Collector: ______________________ LEA Comm. No.: ______________

Field Equipment: ______________________________

Well Number	Collection Date	Total Volume Removed (gal)	Final Field Readings				Color
			Temperature (^{o}C)	pH (su)	Sp. Cond (umhos/cm)	Turbidity (NTU)	

FIELD PERSONNEL

____

____

____

____

____

SIGNATURE: ______________________

F–WDS–F 7/18/95

100 NORTHWEST DRIVE • PLAINVILLE, CT 06062 • (860) 747-6181 • FAX (860) 747-8822

LOUREIRO ENGINEERING ASSOCIATES, P.C. LEA

FIELD DATA RECORD GROUNDWATER

Page ______ of ______

Project: | LEA Comm. No: | Date: / /

Location: | Activity: Start: End:

Client:

Monitoring Well No: | Sample Numbers:

Field QC Data: ☐ Field Duplicate Collected | Duplicate Numbers:

MONITORING WELL DATA

Well Depth ____ ft | ☐ Measured ☐ Historical | ☐ Top of Well ☐ Top of Casing ☐ ______ | Protective Casing Stick-up (from ground) ____ ft | Protective Casing/Well Diff. ____ ft

Well Dia. ☐ 2 inch ☐ 4 inch ☐ 6 inch ☐ ______

Well Material ☐ PVC ☐ SS ☐ ______

Depth To Water ____ ft | Historical Well Depth ____ ft

Well Integrity:	Yes	No
Prot. Casing Secure	☐	☐
Concrete Collar Intact	☐	☐
Well Locked	☐	☐
Other: ______	☐	☐

Height of Water column ____ ft x Casing ☐ .16 gal/ft (2 in) ☐ .65 gal/ft (4 in) ☐ 1.5 gal/ft (6 in) ☐ ___gal/ft (_ in) = Casing ____ gal + Gravel Pack ____ gal

Total gallons purged

Ambient Air VOA ____ ppm

Well Mouth ____ ppm

Interface Detected? ☐ Yes ☐ No | If yes: ☐ Lighter ☐ Heavier

PURGE DATA

Purge Volume	@__ gal	@__ gal	@__ gal	@__ gal	@__ gal
Temp. Deg. C					
pH, Units					
Specific Conductivity, μmhos/cm					
______					

Sample Observations
- ☐ Clear ______
- ☐ Colored ______
- ☐ Cloudy ______
- ☐ Turbid ______
- ☐ Odor ______
- ☐ Sheen ______
- ☐ Other (see notes)

EQUIPMENT DOCUMENTATION

Purging	Sampling	
☐	☐	Centrifugal Pump
☐	☐	Submersible Pump
☐	☐	PVC Bailer
☐	☐	Stainless Steel Bailer
	☐	Teflon Bailer
	☐	Field Filter
	☐	In-Line Filter
☐	☐	______
☐	☐	______
☐	☐	______

Decon Fluids Used
- ☐ Alco-Nox
- ☐ Deionized Water
- ☐ HNO_3/D.I. Water
- ☐ Potable Water
- ☐ TSP solution
- ☐ Methanol
- ☐ ______

Water Level Equip. Used
- ☐ Electric Cond. Probe
- ☐ Solinst Interface Probe
- ☐ Other

Number of Filters Used ______

ANALYTICAL PARAMETERS

	Analyte(s)	Method Number	Filtered? Yes No	Preservation Method	Volume Required	Sample Collected	Sample Bottle ID #	Bottle Lot #
☐			☐ ☐			☐		
☐			☐ ☐			☐		
☐			☐ ☐			☐		
☐			☐ ☐			☐		
☐			☐ ☐			☐		

FIELD PERSONNEL:

Signature: ______

FE-DRG-1 3/18/94

100 NORTHWEST DRIVE • PLAINVILLE, CT 06062 • (860) 747-6181 • FAX (860) 747-8822

An Equal Opportunity Employer

LOUREIRO ENGINEERING ASSOCIATES, P.C.

LEA

WELL INSPECTION CHECKLIST

PROJECT: ______________________ LEA Comm. No.: ______________________

LOCATION: ______________________ DATE: ______________________

CLIENT: ______________________ FIELD PERSONNEL: ______________________

WELL No.: ______________________

WELL INTEGRITY	YES	NO	OBSERVATIONS
WELL LOCATED / FOUND			
PROTECTIVE CASING INTACT			
PROTECTIVE CASING SECURE			
CONCRETE COLLAR INTACT			
COLLAR SIZE (RADIUS)	N/A	N/A	
LOCKING CAP			
WELL LOCKED			
PVC INTACT			
PVC DIAMETER	N/A	N/A	
DEPTH TO WATER	N/A	N/A	
DEPTH TO BOTTOM	N/A	N/A	
HISTORICAL BOT. DEPTH	N/A	N/A	
WELL PLUMB			
OBSTRUCTION TO BAILER			
WAS WELL REDEVELOPED*			
REPAIR WELL			
REPLACE WELL			

* (See Well Development Report)

F–WIC–F 7/9/95

100 NORTHWEST DRIVE • PLAINVILLE, CT 06062 • (860) 747-6181 • FAX (860) 747-8822

LOUREIRO ENGINEERING ASSOCIATES, P.C.

SOIL GAS SURVEY DATA RECORD

Page ________ of ________

Project: ____________________ LEA Comm. No: | | | | | | | | Date: / /

Location: ____________________

BORING LOCATION: ____________________

Sample Name				
Depth				
Vacuum 1				
Flow 1				

Vacuum 2				
Flow 2				

Vacuum 3				
Flow 3				

COMMENTS

Field Blank Collected? ☐ Sample Name ____________________

QA/QC Duplicate Collected? ☐ Sample Name ____________________

FIELD PERSONNEL:

____

____

____

____

Signature: ________________________________

FE-SGS-1 6/17/94

100 NORTHWEST DRIVE • PLAINVILLE, CT 06062 • (203) 747-6181 • FAX (203) 747-8822

LOUREIRO ENGINEERING ASSOCIATES, P.C. LEA

SOIL VAPOR SCREENING SAMPLING RECORD

Page ________ of ________

Project: ____________________ LEA Comm No: ____________ Date: ___ / ___ / ___

Location: ____________________

Sample ID	Depth (ft)	High Reading	Stable Reading	Flow Rate	Comments

FIELD PERSONNEL: ____________________

____

____

____

Signature: ____________________

F–VSR–FA 10/95

100 NORTHWEST DRIVE • PLAINVILLE, CT 06062 • (860) 747-6181 • FAX (860) 747-8822

LOUREIRO ENGINEERING ASSOCIATES, P.C. LEA

FIELD INSTRUMENTATION & QUALITY ASSURANCE RECORD

Page ________ of ________

Project: [ ] LEA Comm. No: [| | | | | |] Date: [/ /]

Location: [ ]

FIELD INSTRUMENTATION CALIBRATION DATA

Instrument Type/I.D. # — Calibration Information

Crew #1	Use	Temp Comp.	Buffers Used/Meter Value	Conductivity Readings
________	☐ pH ☐ Temperature ☐ Conductivity	☐ Yes ☐ No	☐ pH 4 ________ ☐ pH 7 ________ ☐ pH 10 ________	Meter Value Dry ________ Standard Value ________ Meter Value ________
________	☐ pH ☐ Temperature ☐ Conductivity	☐ Yes ☐ No	☐ pH 4 ________ ☐ pH 7 ________ ☐ pH 10 ________	Meter Value Dry ________ Standard Value ________ Meter Value ________
________ ________	PID (VOC Analyzer) ________		☐ Zero w/ Background ☐ Zero w/ Zero Air	Span Gas Value ________ Meter Value ________

Crew #2	Use	Temp Comp.	Buffers Used/Meter Value	Conductivity Readings
________	☐ pH ☐ Temperature ☐ Conductivity	☐ Yes ☐ No	☐ pH 4 ________ ☐ pH 7 ________ ☐ pH 10 ________	Meter Value Dry ________ Standard Value ________ Meter Value ________
________	☐ pH ☐ Temperature ☐ Conductivity	☐ Yes ☐ No	☐ pH 4 ________ ☐ pH 7 ________ ☐ pH 10 ________	Meter Value Dry ________ Standard Value ________ Meter Value ________
________ ________	PID (VOC Analyzer) ________		☐ Zero w/ Background ☐ Zero w/ Zero Air	Span Gas Value ________ Meter Value ________

FLUIDS / MATERIALS RECORD

Deionized Water Source: ☐ LEA Staging
☐ Other ________

Decontamination Fluids: ☐ Alco–Nox
☐ Methanol
☐ 20% HNO_3 — Lot No. ________
☐ Other ________ — Lot No. ________

Calibration Fluids: ☐ pH Buffer — Lot No. ________
Lot No. ________
Lot No. ________
☐ Cond. Standard — Lot No. ________

Filtration Unit: ☐ In Line
Manufacturer: ________ — Lot No. ________
☐ Vacuum
Manufacturer: ________ — Lot No. ________
☐ Pressure
Manufacturer: ________ — Lot No. ________

FIELD PERSONNEL:

Crew #1	Crew #2
________	________
________	________
________	________
________	________
Signature: ________	Signature: ________

FE–IQA–1 3/18/94

100 NORTHWEST DRIVE • PLAINVILLE, CT 06062 • (203) 747-6181 • FAX (203) 747-8822

LOUREIRO ENGINEERING ASSOCIATES, P.C.

FIELD QUALITY REVIEW CHECKLIST

Page ______ of ______

Project: ____________ LEA Comm. No: ____________ Date: / /

Location: ____________

	Yes		No	Corrective Action Taken:
Sample Labels Complete?				
Sample Seals Used?				
Field Log Book Complete?				
All Planned Samples Obtained?				
All Chain of Custody Forms Complete?				
Monitoring Well Physical Data Forms Complete?				
Field Sample Record Forms Complete?				
Daily Field Report Form Complete?				
Field Instrument & Quality Assurance Record Complete?				
Field Data Record – Groundwater Form Complete?				
All Field Generated QA/QC Samples Collected?				
Final Site Walkover Complete?				
Field Quality Review Checklist Complete?				

COMMENTS

FIELD PERSONNEL: ____________

____

____

____

Signature: ____________

FE–FQR–1 3/18/94

100 NORTHWEST DRIVE • PLAINVILLE, CT 06062 • (203) 747-6181 • FAX (203) 747-8822

LOUREIRO ENGINEERING ASSOC., P.C. LEA

SURFACE WATER PHYSICAL DATA

Project Name: Location: LEA Comm: No.: Operator:

Sampling Location	Approximate Location	Gauging Station Elevation (ft)	Depth to Water (ft)	Surface Water Elevation (ft)	Sample Conditions			Date and Time
					pH	Sp. Cond. (µmhos)	Temp. (°C)	

Comments:

7/2/9409:48

LOUREIRO ENGINEERING ASSOCIATES, P.C.

WASTE MANAGEMENT RECORD

Page ________ of ________

Project: | LEA Comm. No: | Date: / /

Location: | Client:

Container Tracking Information

No.	Container I.D.	Container Type	Contents	Generation Location	Start Date	Completion Date	Container Location	Disposition of Contents	Sample Number
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									

LOUREIRO ENGINEERING ASSOCIATES, P.C.

WASTE MANAGEMENT AREA INSPECTION FORM

Page ______ of ______

Project:		LEA Comm. No:		Date:	/ /
Location:		Inspected by:		Time (A.M.):	
Client:		Inspected by:		Time (P.M.):	

Waste Management Area Inspection Checklist

Inspection Point	Description	Condition			Comments
		Good	Fair	Poor	
Drums	Check for integrity, tightness, no free liquid on drum tops, tops secured and bolted, two feet between pallets				
Roll-offs	Check that tarp is secure and fastened with hoops intact, no free liquids, no evidence of leakage				
Bulk Liquid Tanks	Examine for leaks (valves, ports, base); Record levels; Check that valves are locked				Level 300 gal. tank: ______ A.M. ______ P.M. Level 4000 gal. tank: ______ A.M. ______ P.M.
Containment Areas	Check for signs of leakage, integrity of liner				
Security of Areas	Check for caution taping, use of spill pallets; Check availability of spill kits and overpacks				
Labels	Check to see that labels are turned to outside and that writing is legible and complete				

Drum Inventory	No. of Drums	
	A.M.	P.M.
Empty Closed-top		
Empty Open-top		
Used Closed-top		
Used Open-top		

Additional Comments:

F-WMC-F 8/2/95

100 NORTHWEST DRIVE • PLAINVILLE, CT 06062 • (860) 747-6181 • FAX (860) 747-8822